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ART. XXXV.—*On the Cause of the Arid Climate of the Western portion of the United States;* by Captain C. E. DUTTON, U. S. A., U. S. Geological Survey.

Read before Section B, American Association for the Advancement of Science, Cincinnati Meeting, Aug. 18th, 1881.

MANY questions arising in the study of western geology involve the consideration of the arid climate of the region, and I have frequently been led to inquire as to its cause. Arid climates are usually attributed to the passage of prevailing winds over high mountain chains. As they ascend the mountains upon the windward sides they are cooled by the expansion due to diminished barometric pressure, their capacity for moisture is reduced and an abundant precipitation takes place. Descending upon the leeward sides these changes are reversed; the air is heated, its capacity for moisture is increased, it becomes dry, and having been depleted of moisture is supposed to be incapable of yielding a copious supply to regions beyond. This explanation is no doubt good for some localities. Peru is a case in point and for that country it seems quite perfect. It is believed by many that it also explains the arid climate of the western half of the United States, and that the Sierra Nevada is the range which robs the winds of that region of the moisture which otherwise would make its vast expanse fertile. Reflection upon this case has led me to a different conclusion.

It is unquestionable that the Sierra Nevada abstracts a notable amount of moisture from the winds blowing from the

Pacific. Mr. B. B. Redding, the Land Agent of the Central Pacific Railroad, has kept for several years excellent records of the rainfall at many stations in California and Nevada, and informs me that along the main road from Sacramento to the summit pass of the Sierra, the annual rainfall increases at the rate of one inch for every one hundred feet of altitude. At the summit the mean annual precipitation exceeds ninety inches. It is not improbable that this large amount is considerably exceeded at numerous points along the crest of the range. It seems clear therefore that the winds which blow over the Sierra are to some notable extent depleted of moisture and the effect must be to at least aggravate the aridity of the regions lying immediately east of the range. But I think it can be made evident that this effect is relatively not great, and that the elevated region of the west would be on the whole very nearly as arid as it now is if the Sierra Nevada were obliterated as a mountain range. Nor can the other and lower ranges lying east of the Sierra affect the case materially, for surely more than ninety per cent of the rain and snow which fall upon them are reëvaporated *in loco* and the atmosphere ultimately suffers no material loss of moisture.

When the winds blow constantly from a cool to a warmer region they become warm and therefore dry; and if they have no opportunity to take up more moisture on the way the passage from a cool to a warm region is a sufficient cause of aridity. This is, I conceive, the state of affairs which determines the climate of the western mountain region. The winds blow constantly from the western quarters, being the "return-trades." Local winds and perhaps large cyclones occasionally turn the weathercock toward an easterly quarter, but the general drift of the great atmospheric ocean is ever from west to east.* This prevailing air drift comes from the Pacific and reaches the coast nearly or quite saturated with moisture. The quantity of moisture required for saturation is dependent chiefly upon temperature; and the temperature of the air as it reaches the coast is determined by oceanic conditions.

From the Aleutian Islands a coastwise ocean-current moves southward, having a breadth of 500 miles or more, and extending as far southward as the latitude of Cape St. Lucas. Off British Columbia and Alaska it may be regarded as a warm current relatively to the adjoining land. Off the Californias although its temperature rises notably with its southward movement it may be regarded as a relatively cool current. On the more northerly shores its effect is to make the climate of the adjacent coast warmer than it would otherwise be; and its

*This general statement requires some qualification when applied to southern Arizona and southern New Mexico, though it is in the main applicable even there.

effect on the more southerly shores is to make them cooler. Stated in another manner the relation is such that the temperatures of the land areas in the high latitudes are lower than those of the ocean, while in the low latitudes they are higher. In the high latitudes, therefore, the winds blowing from the Pacific are cooled by the land; in the low latitudes they are warmed by it. Hence the precipitation is copious in the former regions and meager in the latter. Between the two belts where these opposite effects are pronounced is a region where they shade into each other, and though this intermediate region cannot be marked out by distinct boundaries it may still be said to exist in latitudes lying within the valley of the Columbia River.

The cause of an arid climate thus indicated may be regarded as generally operative throughout the western mountain region; and it will no doubt appear upon full consideration to be much more potent and widely extended in its action than any or even all of the mountain ranges could be. It is, however, greatly modified by the intervention of local causes, which occasionally mask or obscure it. The precipitation in different portions of the region is highly irregular and several modifying causes can be indicated which, though they do not nullify the more general one here set forth, frequently become much more conspicuous in their effects. For instance, it is well-known that the heaviest rainfall in the United States, excepting possibly upon some mountain tops, occurs upon the coast of Oregon and Washington Territory. But as already indicated this is the locality where we find the neutral axis, so to speak, of the alleged causes favoring respectively humidity and aridity, and where their effects are at a minimum or even at zero. Moreover, the westerly winds saturated with moisture here strike the coastwise mountains, and are suddenly thrown upward several thousand feet before they have had time to feel the heating effect of the land which is here very slight; and the precipitation is thus very copious. Descending to lower levels inland they soon become dry and produce a sub-arid climate.

The most frequent variants of climate are the great differences of altitude in different portions of the west. The mountain tops and summits of the plateaus are always well watered, and in any given latitude the rainfall increases or diminishes at a fairly definite rate with the altitude. But the variation of rainfall with altitude is by no means a simple ratio. Between 4500 and 6000 feet the difference in rainfall is not great; between 6000 and 7500 feet it is very considerable; between 7500 and 9000 it is still greater.

Moreover the rainfall is greater *ceteris paribus* in high latitudes

than in low latitudes. In passing from the southern to the northern boundary, if we compare localities of equal altitudes along any given meridian, we shall find the rainfall steadily though perhaps not uniformly increasing. This is an obvious consequence of the theory suggested.

Although no very great effects upon the general condition of aridity are here attributed to the depletion of moisture by the passage of the winds over mountain ranges, it is still true, no doubt, that highly important local effects are thereby produced. The rainfall at the eastern base of the Sierra Nevada, and for two hundred miles east of it is most probably reduced very greatly by this cause. In the sink of the Humboldt River, the annual precipitation seldom reaches four inches, and may average not more than three inches. But as we pass eastward beyond the *wake* of this range, its effects become gradually less; and long before the Wasatch is reached they have become inconsiderable. Since the Sierra Nevada is the longest, highest and widest of the individualized ranges of the Rocky system, its local effect upon the humidity of the plains and valleys lying immediately under its lee is greater than that of any other. But the same kind of effect is preceptible in some other ranges.

The discussion of the causes of local variations in climate might be almost indefinitely extended. Nothing more is designed here than to advert to one general cause of aridity which prevails over the entire region, and which everywhere persists, though it is often obscured, sometimes reversed and sometimes reinforced by local causes.

ART. XXXVI.—*On additional Embryonic Forms of Trilobites from the Primordial Rocks of Troy, N. Y., with observations on the genera Olenellus, Paradoxides and Hydrocephalus;* by S. W. FORD.

AMONG the various species of Trilobites of the genus *Paradoxides* (abstracting those forms of which we know the thoracic structure but imperfectly or not at all), there may be distinguished two principal groups: One characterized by having the *second*, and rarely also the *first*, pleuron prolonged considerably beyond the succeeding ones; and the other by having all of the anterior pleura, as we proceed backward, decreasing or increasing in length, according to the species, in a regular manner. As examples of the former we may instance *Paradoxides spinosus* from the Bohemian Primordial, and *P. Bennettii* from that of Newfoundland (and the majority of the Bohemian species

might be included); and of the latter the most if not all of the British species, all of the Swedish, and the American *P. Harlani*. Why two species, so closely allied as are the *P. spinosus* and *P. Harlani*, should yet differ in the particulars mentioned, has all along been looked upon as a mystery; but there can be but little doubt that all who have seriously contemplated the matter, have regarded these differences as possessing a deep and peculiar significance.

The five known species of the American genus *Olenellus* admit of a similar grouping, and, if we confine ourselves to the adult forms alone, upon the ground of thoracic differences equally pronounced with those obtaining in the genus *Paradoxides*. Three of them, *O. Thompsoni*, *O. Vermontanus* and *O. Gilberti* have the *third* pleuron conspicuously prolonged beyond the others; while in *O. asaphoides* it forms, with those preceding and succeeding it, a regularly graduated series. The thorax of the fifth species, *O. Howelli*, has not been observed. These differences long since attracted the attention of paleontologists, and led at least one authority to exclude the *O. asaphoides* from the genus altogether,—apparently overlooking the fact that a similar course of reasoning would compel us to break up the genus *Paradoxides*.* But the facts now in hand show that *Olenellus asaphoides* is, beyond a doubt, a genuine *Olenellus*. As I shall have frequent occasion, in the course of this article, to refer to both the long and short ribbed forms spoken of, I shall designate them, whether referring to *Paradoxides* or *Olenellus*, as the *macropleural* and *brachypleural* types respectively. These

OLENELLUS ASAPHOIDES *Emm.*, SP.

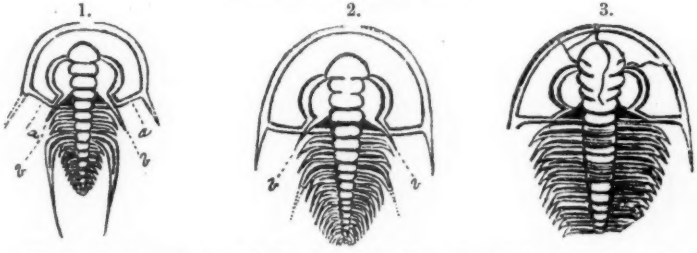


Fig. 1.—Embryonic form of *Olenellus asaphoides*, enlarged five diameters. Fig. 2.—Another specimen, representing a more advanced stage of development, enlarged four diameters. Fig. 3.—A still older specimen, the characters of which are all only those of the adult, enlarged two diameters.

terms, however, as will be seen further on, are not intended to be expressive of sharply defined or clearly distinct groups or sub-groups, but are here introduced merely for the sake of convenience.

* Thirteenth Regents' Report on the N. Y. State Cabinet, p. 119.

As the result of some recent researches in the Primordial beds of Troy, N. Y., I have obtained two specimens which afford a very satisfactory solution of the structural peculiarity noted above in the case of *Olenellus asaphoides;* besides offering a probable explanation of the brachypleurism observed in *Paradoxides.* They tend, moreover, to prove that the macropleural species of that genus should be regarded as typical. Both are young specimens of *Olenellus asaphoides* and unusually perfect. Their leading characters may be stated as follows:

Fig. 1 represents the younger and by far more important specimen, the place of which, in the embryonic series, is probably about mid-way between the forms represented by figures 2 and 3 of my former article (this Journal for April, 1877). There are either nine or ten body-segments, the last three or four being somewhat indistinct. The third pleuron is considerably larger and longer than the others, the points extending backward well beyond the limits of the thorax. All of the pleura have the characteristic groove of *Olenellus.* The posterior margin of the head is sharply geniculated at the sutures, throwing the genal spines notably forward upon the cephalic periphery, precisely as in *Paradoxides spinosus* Boeck and *P. pusillus* Barrande (see figs. 5 and 6). The interocular spines are prominent, and, although slightly damaged, can be seen to have reached nearly to the third body-segment. Moreover, these spines and the genal spines are still parallel with each other as in earlier embryonic life. The glabella is marked by three furrows besides the neck-furrow, all of which run entirely across it as in the known preceding stages of development.

BOHEMIAN PARADOXIDES.

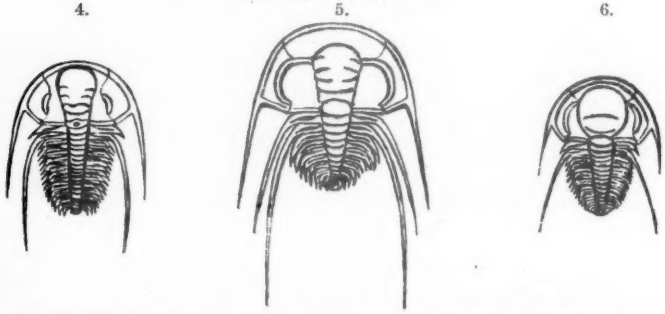


Fig. 4.—Young specimen of *Paradoxides spinosus* Boeck sp., twice enlarged.
Fig. 5.—Very perfect specimen of *P. pusillus* Barrande, enlarged 10 diameters.
Fig. 6.—Complete individual of *P. inflatus* Corda, enlarged 4 diameters. All after Barrande.

The length of the specimen, from the middle of the front margin to the extremity of the third pleuron, is 0·26 of an inch,

and the width of the head, exclusive of the posterior spines 0·14. The entire surface is plain, or without any trace whatever of ornamentation.

Fig. 2 represents the second and older specimen, the left-hand portion of which is partly restored in the drawing. The place of this specimen in the developmental series removes it a number of steps from the form just described, allying it much more nearly to those forms in which the metamorphoses are at an end. There are fourteen body-rings, and behind these a minute, rudely semi-circular plate (the pygidium), which I believe to have been the source of all the body-segments. The third pleuron is still conspicuously longer than the others; but its relative width, as compared with that in fig. 1, is much reduced, and its direction changed. How far backward it extended it is impossible to say, as both the right and left hand points are wanting; but the pleural furrows are here relatively much shorter than in fig. 1, and this fact strongly argues a corresponding abbreviation of the pleural points. The head forms rather less than a semi-circle, and has the posterior margin curved slightly forward; in other specimens, however, of the same size, and even smaller, the posterior margin is completely transverse, and hence the curving in the present instance is evidently an individual peculiarity. The interocular spines are very small, but are still attached to the fixed cheeks. The genal spines are slender, reach as far backward as the third pleura, and here form with the interocular spines a very appreciable angle. The glabella is somewhat crushed, but is seen to be furrowed nearly as in the adult. I cannot say with certainty whether all of the furrows in advance of the neck-furrow were separated on the median line or not. The surface is nearly smooth, but just beyond the eyes some obscure striation can be detected. The length of this specimen is 0·33 of an inch, and the breadth at the genal angles 0·24.

In fig. 3, which is an outline representation of fig. 5 of my former article, the third pleuron forms, with the others, a regular series, the interocular spines have disappeared, the head has assumed the form which it afterward retains, and the development is completed. Between this form and the preceding one, I have a considerable number of others, which leave no doubt as to their being fundamentally one and the same.

We learn, from the foregoing, the important fact, that the macropleural and brachypleural types under the genus *Olenellus* can in no wise be regarded as indicative of fixed or independent groups, *O. asaphoides* being macropleural in embryonic life and brachypleural in the adult; and this breaks down the dividing line between them. Now, according to a well-known

canon in Natural History, *O. asaphoides* must be regarded as higher in grade than its macropleural congeners; and this being true, we are naturally led to inquire whether the brachypleural forms under the genus *Paradoxides* are not also higher in grade than *their* macropleural congeners. Unfortunately, the direct evidence required to decide this question is wanting; but there are certain known facts having an important bearing upon it, and to these I shall now refer.

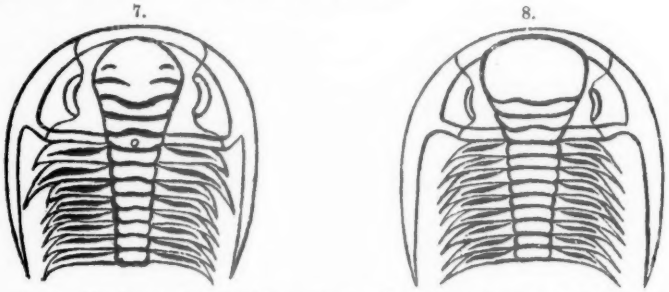


Fig. 7.—Head and first 8 body-segments of adult specimens of *Paradoxides spinosus* (macropleural), reduced two-thirds. Compare with fig. 4. Fig. 8.—Head and 9 forward pleura of adult of *P. Tessini* Brongn. (brachypleural), reduced one-half (after Angelin).

Among the macropleural *Paradoxides* described by Barrande, there are a number of species of which we lack either one or other of the growth extremes; some of them being known only by adult examples, and others only by forms which appear to be the young. I say *appear to be*, because, while I have myself no doubt that *P. pusillus* is a young Trilobite, there is nothing in the aspect of *P. inflatus* except its small size and excessively produced second pleura to indicate that it was not full grown. In the case of *P. spinosus* and *P. Bohemicus*, however, we know both the young and mature forms; and, as will be seen by figure 4, *P. spinosus*, in the young state, was not only pronouncedly, but even extravagantly, macropleural, the points of the second body-segment extending, like those of the third in the young of *O. asaphoides*, backward beyond the thorax; and in the young of *P. Bohemicus* this peculiarity is equally striking. But although this feature, in both of these species, was well-nigh obliterated in the adult, yet in neither was the process carried sufficiently far to render them brachypleural species. Nevertheless, it is not difficult to see that such a result might easily have been attained; and from what we now know of the history of *O. asaphoides*, coupled with the facts just stated, there is strong presumptive evidence that the brachypleural species of *Paradoxides* were macropleural in early

life. It is earnestly to be hoped that the British and Swedish *savans* will institute, at no distant day, new researches, with the view of reaching a clear and final settlement of this important question.

But by far the most interesting feature of the young specimen of *Olenellus asaphoides* first described yet remains to be particularly considered. I allude to the remarkable *Paradoxides*-like run of the outer portion of the posterior margin of the head, shown at *a a* in figure 1. This feature, though varying in the intensity of its expression in the several species, is, if we exclude one or two species which are in other respects abnormal, constant in the genus *Paradoxides*, and appears to have been especially emphasized in the forms of the macropleural section; but it is shown in none of the other species of the genus *Olenelius*, and even disappears altogether, as we have seen, in *O. asaphoides*, during embryonic life. After much study of the subject, I am convinced that we have here the exhibition of a character, afterwards lost, which in *Paradoxides* may be regarded as fixed. It is true, that in *O. Gilberti*,* the posterior margin is deeply emarginate in the vicinity of the postero-lateral angles; and this feature, as shown by the figures given in the Vermont Geological Reports, is sometimes present in *O. Vermontanus;* but the facial suture, in the former species, does not cut the posterior margin at the point of geniculation as in *Paradoxides*, but far within it; and this appears to hold good for the youngest specimen which Dr. White figures. It is evident, to my mind, that this character is not the same with that under discussion occurring in the young of *O. asaphoides;* and I believe that no one, who will take the trouble to examine the facts, will be likely to reach a different conclusion. The discovery, however, of still younger specimens of *O. Gilberti* is greatly to be desired, as they would doubtless serve to throw much light upon the whole question.

Now, if the foregoing interpretations be correct, *Olenellus asaphoides* must be regarded as higher in grade than any of the normal species of *Paradoxides;* and such I believe its history and structure alike declare it to be. The following additional facts and considerations appear to me to sustain this conclusion, and tend to clear up a number of points hitherto obscure connected with the subject.

Fig. 10 represents the plan of structure of the head of a Swedish *Paradoxides*, described by J. G. O. Linnarsson, in 1871, under the name of *P. Kjerulfi*.† The thorax in none of the examples figured is well preserved, but from the study of

* White, Rep. upon Geogr. and Geol. Explor. and Surv. west of the One Hundredth Meridian. Part I, vol. iv, Paleontology, p. 44, pl. 2 figs. 3 a–c.

† Oefversigt af Vetenskaps-Akademiens Förhandlingar, 1871, No. 6, Stockholm.

the head alone, no one thoroughly acquainted with Primordial Trilobites would hesitate to pronounce it a *Paradoxides;* and M. Linnarsson thus unquestioningly describes it. It is only when we come to compare it with such forms as *Olenellus*

9. 10. 11.

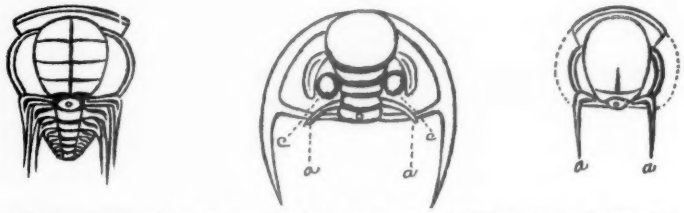


Fig. 9—Head (minus the free cheeks) and thorax of *Hydrocephalus Saturnoides* Barrande, enlarged 16 diameters. Fig. 10.—Plan of structure of the head of *Paradoxides Kjerulfi* Linnarsson, from the Swedish Primordial, nat. size. Fig. 11.—Head of *Hydrocephalus carens* Barrande (the free cheeks restored in outline), enlarged 6 diameters.

asaphoides and *O. Gilberti*, and especially with the young of the former, that the real difficulty arises. It differs from the other forms of the genus mainly in: (1) The possession of a pair of spinous processes extending from the neck-furrow backward across the posterior margin (fig. 10, *a a*); (2) The apparently firmly soldered facial sutures; and (3) The marked tumidity of the central portions of the fixed cheeks (fig. 10, *c c*). All of these characters, if we regard the spinous processes as the structural homologues of the interocular spines of *Olenellus asaphoides*—see figs. 1 and 2, *b b*—(and whether so or otherwise, I believe them to have been clearly functionally such) occur likewise in *O. asaphoides;* the first and third having here, however, only a transitory existence, while the second characterizes all the stages. *O. asaphoides* further shows its close relationship with the Swedish form in having all of its glabellar furrows, in early embryonic life, extending entirely across, instead of being interrupted, as in the more advanced and mature forms, on the median line. There can be scarcely a doubt that the figure of *Paradoxides Kjerulfi* above given represents a fully developed form, and that all of the characters which it exhibits were permanent in it.*

The above facts, taken in connection with those stated earlier, strongly argue that *Olenellus asaphoides* may be safely regarded as higher in grade than any known form of *Paradox-*

* It is worthy of remark, in this connection, that the solidity of the head-shield, due to the firm coalescence of the free and fixed cheeks in front of the eye, appears to have characterized all the known species of *Olenellus;* and that in one of them at least, *O. Thompsoni* (fig. 12), the central portions of the fixed cheeks, or interocular spaces, were notably inflated in adult life.

ides whatsoever; *P. Kjerulfi* being a normal species in so far as concerns the contour of the posterior margin of the head, but in other particulars one of the most widely divergent; and we here touch, it seems to me, the real core of the matter. The all-important question is, what is the precise nature of the relationship subsisting between these two species? We might, indeed, rest content with the deductions already arrived at and the inferences to which they lead; among which latter may be mentioned this: that if *O. asaphoides* has the superior zoological rank above accredited to it, it is probably a more recent form; and this fact accords well with the collective testimony of the other forms composing the local fauna (that of Troy, N. Y.,) to which it belongs; but are not the special relationships pointed out, one and all, the mere incidents of some profounder, all-embracing relationship? That such they are I cannot well doubt; and I am further compelled to add, that the study of the facts herein presented has produced in my mind a strong conviction that this relationship is probably deeper than an ordinal, a family, or even a generic one—in short, that it is genetic. And that this view of the case will ultimately prevail, there is, in my opinion, every reason to believe.

The weight of the evidence in this case may perhaps be better appreciated by a succinct restatement of it, and it amounts to this: that four out of five of the fixed characters of *P. Kjerulfi* above enumerated appear in the extreme young of *O. asaphoides* only to disappear; and in addition to this it loses during early life, as we have seen, its macropleurism. Had we but a single embryonic character linking this species with *Paradoxides* the case would be different, but we here have a whole congeries of such characters, clearly and unmistakably shown. It is true that, in his later writings (1879), M. Linnarsson refers to *P. Kjerulfi* as *Paradoxides* (*Olenellus*) *Kjerulfi;* but in 1877, shortly after the publication of my former article, we find him changing the title of *O. asaphoides*, as given by me, to *Paradoxides* ("*Olenellus*") *asaphoides;* that is to say, he endeavored to get over the difficulty by first turning *O. asaphoides* into a *Paradoxides*, and then turning *P. Kjerulfi* into an *Olenellus*, neither of which attempts have proved, however, at all satisfactory. I believe that, even if *O. asaphoides* be genetically related to *P. Kjerulfi*, we may yet with propriety consider it as generically distinct, and as such I still continue to look upon it. Nevertheless, I am free to own that, if we take into account the entire known range of structural characters under the genus *Paradoxides*, I see nothing, at present, in the finished form of *O. asaphoides*, that can be regarded as absolutely distinctive, except the segment furrow. If it be true that *O. asaphoides* has resulted from

the evolution of some *Paradoxides*-like form, then the line of descent probably extends backward through the macropleural section of the genus *Olenellus* to some such species as *Paradoxides Kjerulfi*, or perhaps to some still more divergent form of *Paradoxides*, with which we are as yet unacquainted.

12. 13.

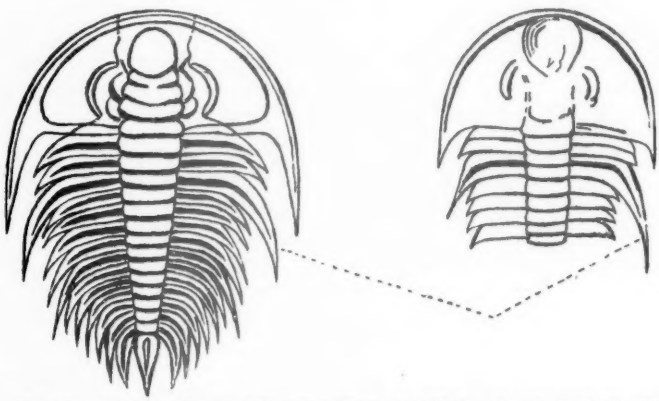


Fig. 12.—Adult specimen of *Olenellus Thompsoni* Hall, reduced one-half. Fig. 13.—Medium sized individual of *O. Vermontanus* Hall, natural size. Both after Hall.

Hydrocephalus is a still somewhat obscure genus occurring in the Bohemian Primordial; but, as long since pointed out by Barrande, one of the close allies of *Paradoxides*. It differs from *Paradoxides* mainly in the course of its facial sutures, and in the peculiar position of its genal spines; the former striking the posterior margin, according to Barrande, in such a way as to leave the latter attached to the fixed cheeks (see fig. 11, *a a*). Barrande considers the head to have had the form shown in the figure referred to, but the free cheeks have never been observed. Hence a doubt may well exist as to whether what he here calls the genal spines are truly such. M. Linnarsson considers them the probable homologues of the spines of the fixed cheeks of his *Paradoxides* ("*Olenellus*") *Kjerulfi*, and the interocular spines of *Olenellus asaphoides*. It is possible that his view is the correct one, and, if so, the head, when perfect, probably had much the form of that in fig. 6. At present, however, I do not share this opinion, believing them to be altogether peculiar. The discovery of a perfect specimen is greatly to be desired. *Anopolenus* (Salter) is another of the close allies of *Paradoxides;* and in the *P. expectans* of Barrande (Syst. Silur., etc., vol. i, supplt., pl. 3, figs. 33–35, and pl. 14, fig. 35) we have a type so closely resembling it as to strongly

suggest for them a genetic kinship (see Hicks, Quart. Jour. Geol. Soc., vol. xxviii, pl. 7, figs. 1–11). Salter states that, in the British Primordial, the genera *Paradoxides*, *Anopolenus* and *Olenus* follow each other in regular order—first *Paradoxides*, then *Anopolenus* and lastly *Olenus;* and in America we appear to have a like succession—first *Paradoxides*, then *Olenellus*, and lastly the Olenoid types of the western States.

The remarkable intersection of differential characters observed in the embryonic forms of *Olenellus asaphoides*, and the transformations there noted, appear to me to point to the *Embryo* as the principal theatre of organic evolution in general; and they strongly suggest, to my mind, the operation of profounder laws than any, hitherto assumed, as having effectively directed its course. It seems well-nigh absurd to ascribe such effects to natural selection, or the influence of environmental conditions, although such influences have, no doubt, to some extent, modified the total result. So far, however, as we are enabled to judge, the conditions of existence in Primordial times were remarkably uniform, and the "struggle for existence" was probably less a struggle then than now. And if it be true that the transformations wrought were mainly completed in embryonic life, and that, too, largely independent of external influences, it is no wonder that the great wealth of Silurian life still lies before us practically a sealed book, for it is only in exceptional instances that we may hope to be permitted to study the embryology of animal forms long extinct.

In the preparation of this paper I have all along felt my own unworthiness to deal in a befitting manner with the difficult problems which its subject matter presents; while as concerns the principal conclusion reached, or that touching the question of genesis, I should prefer to be understood as expressing in it rather my present convictions than my mature or final judgments. Nevertheless, I believe it to have a veritable basis in the known facts, and that its presentation is fully warranted by them; but those better qualified to judge may decide differently, and thus the real truth of the matter, even if I have missed it, will be likely, sooner or later, to come out. I have thought it well to assume but little, and to proceed according to the light of the evidence.

June 13th, 1881.

ART. XXXVII.—*Observations of Comet b*, 1881, *made at the Washburn Observatory, University of Wisconsin, Madison;* by EDWARD S. HOLDEN.*

THE following observations of the bright comet of 1881 have been made at the Washburn Observatory, with the Clark equatorial of 15·5 inches aperture, mostly with an eye-piece magnifying 145 diameters, having a field of 25′·5.

The accompanying engravings first appeared in *Science* of July 23 and August 6, and have been kindly furnished by the editor. In these (except in the case of the drawing of July 11), the darker the shading the brighter the corresponding part of the comet.

The Washburn Observatory is $0^h\ 49^m\ 25^s{\cdot}8$ west of Washington. The *times* are, however, Chicago mean times, or correspond to a meridian $0^h\ 7^m\ 11^s{\cdot}1$ east of our own, that is $0^h\ 42^m\ 14^s{\cdot}7$ west of Washington.

1.

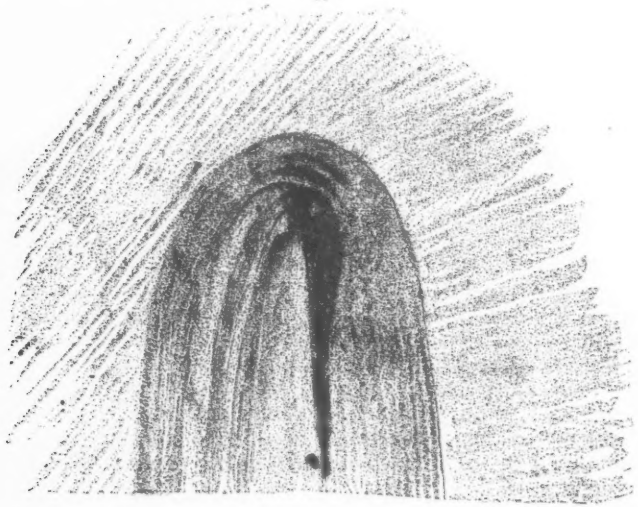
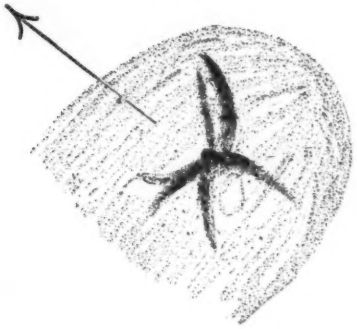


Figure 1; June 24, 14^h m. t.—This figure is intended to show the whole structure of the head of the comet, with its envelopes. There is a star within the tail.

Figure 2; June 25, 10^h m. t.—Sky hazy and outlines of the comet not well seen. The drawing shows only the structure of

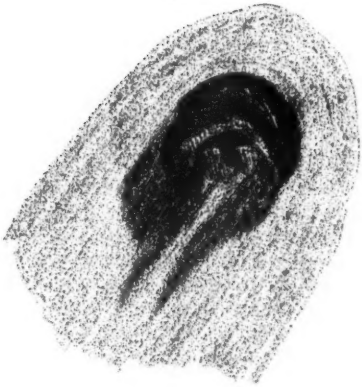
* For the cuts illustrating Professor Holden's paper, this Journal is indebted to Mr. John Michels, editor of "Science," in whose pages the above illustrations were first published.

2.



June 25.

3.



June 26.

4

June 27

the head. The nucleus is not round and is eccentric in the envelopes. The arrow shows the parallel.

Figure 3; June 26, $11^h\ 22^m$ m. t.—Hazy and cloudy.

Figure 4; June 27, 13^h m. t.

5.

6.

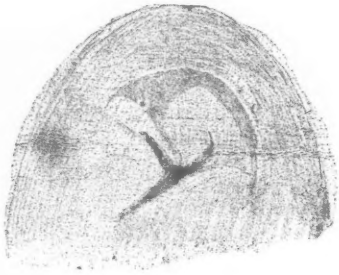


Figure 5; June 28, 10^h m. t.

Figure 6; June 29, $9^h\ 30^m$ m. t.—I was absent from Madison till July 8.

7.

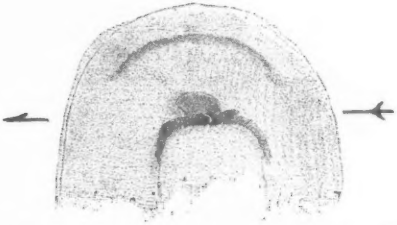


Figure 7; July 8, $10^h\ 35^m$ m. t.—Moonlight. The nucleus is not double. There is a dark narrow channel between the following side of the nucleus and the envelopes, as in the figure.

8.

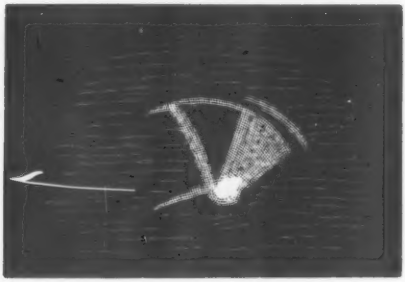
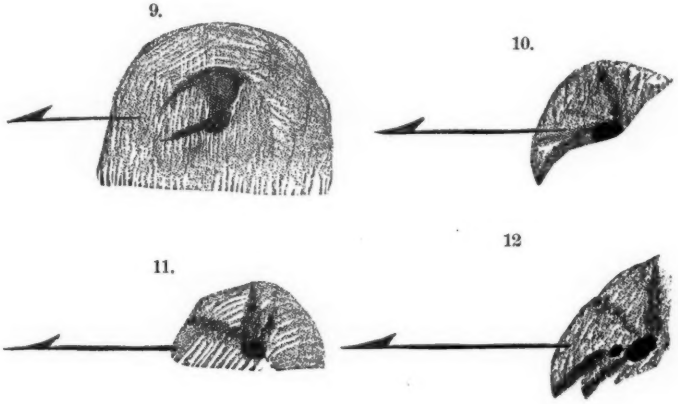


Figure 8; July 11, $9^h\ 30^m$, m. t.—Strong moonlight and twilight. This cut gives bright portions of the comet by white lines.

Figure 9; July 13, $9^h\ 30^m$ m. t.
Figure 10; July 14, $10^h\ 20^m$ m. t.—Moonlight.
Figure 11; July 17, $10^h\ 45^m$ m. t.
Figure 12; July 18, $9^h\ 30^m$–$11^h\ 0^m$ m. t.—The nucleus is double (it has not been previously), $p=275°$, $s=1''{\cdot}5$, with a dark space between the parts.



July 19; $9^h\ 45^m$ m. t.—Appearances same as last night, but fainter. The nucleus is elongated in $p=280°\pm$. The second nucleus is in $p=270°$ $s=1''$ to $2''$.

July 24; $9^h\ 35^m$ m. t.—The nucleus is double, $p=225°$ (4) $s=2''{\cdot}62$ (3). The diameter of the principal nucleus in $p=135°$, is $1''{\cdot}68$ (2).

The micrometer measures by Mr. Burnham.

July 26; $9^h\ 3^m$ m. t. The nucleus is round.

July 27; $10^h\ 10^m$ m. t.—The nucleus seems elongated in $p=250°$, but I am not sure.

After this date the comet was examined on several occasions without finding any peculiarity worthy of mention. It is to be noted that there is no doubt whatever as to the fact that the nucleus was double on July 18, July 19 and July 24. I am almost equally positive that it was not double on the other dates specified.

It appears to me that these observations are of interest in connection with those of Prof. O. Stone at the Cincinnati Observatory, and of Mr. Wendell at the Harvard College Observatory.

Washburn Observatory, Madison, Wisconsin, August 25, 1881.

Art. XXXVIII.—*On the thickness of the Ice-sheet at any Latitude;* by W. J. McGee.*

1. Estimates of thickness.

First preliminary estimate.—It was shown in Part I of this paper that the accumulation of glacier ice is dependent on precipitation; and in a general way it may be considered proportional therewith. It may also be assumed that the precipitation, and hence of course the accumulation of ice, is proportional to the vapor-tension. If then the thickness at any latitude is known, that at all other latitudes can be readily computed.

Professor Dana has shown † that the thickness of the Quaternary ice-sheet over the Canadian highlands (about N. lat. 48° to 50°) must have been at least 12,000 feet. As this accumulation took place under conditions less favorable than those considered in the present discussion, it may be assumed that a thickness of three miles might obtain at lat. 40°. The thickness at each latitude from 40° to the pole would accordingly be as represented in table XVII. The data forming the basis of the computation are derived from sources previously enumerated.

Table XVII.

Greatest thickness of Ice-field from lat. 40° to the Pole.

Latitude.	Temperature.	Vapor-tension.	Thickness of ice.
40°	+56·5° F.	0·457 in.	3·000 miles.
50	41·7	·264	1·733
60	30·2	·168	1·103
70	16·0	·090	·591
80	6·8	·059	·387
90	2·3	·048	·315

Second preliminary estimate.—It would doubtless be more satisfactory to base estimates upon the present accumulation of ice over polar regions, if the quantity were at all definitely known. The uncertainty regarding the exact amount is so great, however, especially in arctic regions, that any such estimate will serve only as a check on that already made.

It may be almost arbitrarily assumed that, if the land ice existing on the zone bounded by the eightieth parallel were uniformly distributed, it would form a sheet fifty feet in thickness. Now too little aqueous vapor is conveyed into arctic regions to permit the accumulation of sufficient ice to form an effective condenser. It is probable that, in consequence of this imperfection

* This article is from Mr. McGee's paper on "Maximum Synchronous Glaciation," making 65 pages of the Proceedings of the American Association for the Advancement of Science, vol. xxix, 1880.

† This Journal, March, 1873.

of the arctic condensing apparatus, enough moisture is not congealed, but allowed to fall as rain and thus to melt a portion of the ice, to reduce the accumulation which should take place by fully two-thirds. Were it not for this the accumulation might reach 150 feet on an average, and 300 feet near the margin. The corresponding maximum thickness when the ice extended ten degrees farther from the pole would be about 400 feet. These estimates enable us to institute a comparison with the antarctic ice-sheet.

Only about one-seventh of the seventieth parallel of north latitude is so free from land as to present no obstruction to the carrying in of vapor from more southerly regions. In the southern hemisphere, on the other hand, the whole parallel is practically open to the introduction of vapor from the adjacent temperate zone. The accumulation here ought accordingly to be seven times as great as in arctic regions, or 2,800 feet near the margin. It will probably not be objected that these estimates are too low, as they have purposely been made as large as seems at all consistent with the present condition of polar regions. It has already been shown that the present accumulation in these regions is probably about as great as ever can have existed.

Accepting the largest of these estimates as representing the greatest possible thickness of the ice-cap at lat. 70°, and computing the thickness at other latitudes as in table XVII, the respective values are found to be as follows:—

Lat.	40°	14217 feet,	= 2·693	miles.
"	50	8213 "	= 1·555	"
"	60	5226 "	= ·990	"
"	70	2800 "	= ·530	"
"	80	1835 "	= ·348	"
"	90	1493 "	= ·283	"

The approximate correspondence between the two estimates is apparent.

Final estimate.—It may be assumed that, in a hemisphere with parallel isotherms and isobars, all vapor is precipitated nearer the poles than where it is formed. Two factors (perhaps unequal), tending to produce opposite results in the final computation, will be disregarded. These factors are (1) the elevation of temperature outside the ice-field illustrated by table VI, and (2) the less frequent saturation of the atmosphere in frigid climates. As shown by the tables of Section II, when the ice-sheet reached any latitude the vapor which had previously been borne polar-ward would be precipitated near the margin of the sheet, mainly in the form of snow. The precipitation would hence be greater than the normal, at the border of the ice, in the ratio of $p : p + \frac{po}{n}$, where p denotes normal precipitation, o

area of zone bounded by margin of ice, and n area of hemisphere. Table XVIII has been computed in accordance with this ratio.

TABLE XVIII.

Maximum thickness of Ice-cap.

Latitude.	Temperature. —Dove.	Vapor-tension.	Value of $p+\frac{p\,o}{n}$.	Thickness of Ice-cap. Feet.	Miles.
10°	+79·9° F.	1·020 in.	1·863	55,871	10·582
20	77·4	·940	1·559	46,753	8·855
30	69·8	·728	1·092	32,749	6·203
40	56·5	·457	·620	18,594	3·422
50	41·7	·264	·326	9,777	1·852
60	30·2	·168	·191	5,728	1·085
70	16·0	·090	·095	2,800	·530
80	6·8	·059	·060	1,799	·341
90	2·3	·048	·048	1,440	·273

It is almost needless to reiterate the proposition already demonstrated, that vapor could not be borne far enough within the margin of the ice to affect materially the above results, without seriously deranging the sequence of phenomena to which the ice owes its origin and conservation.

The suggestion that the property of flowing might enable the ice to assume a uniform depth may be anticipated by mentioning that the polar slope above given is less than one-tenth of that requisite, according to Hopkins's experiments, to produce the slightest motion.

2. Comparison with the ice-cap theory.

Concomitants of the theory.—The ice-cap theory seems to have been framed chiefly to account for the equatorial motion of the Quaternary glaciers. Now, to be consistent with itself, the theory requires that the assumed thickness of the cap shall be sufficient to form a slope down which ice will flow by gravitation alone. Hopkins found that ice barely moves on a slope of one degree; and there is no evidence that existing glaciers move on a less slope. To form such a slope from lat. 40° to the pole, the polar thickness of the ice would have to be 60 miles—the "twenty leagues" of Adhemar. If, with the same mean thickness, it extended only to lat. 45°, the content of the cap would be 575,000,000 cubic miles, equal (the density of ice to water being as ·92 to 1) to 529,000,000 cubic miles of water. But taking the water-area of the globe at 145,000,000 square miles, and the mean depth at 12,144 feet, or 2·3 miles,* we find that

* Sir Wyville Thompson says: "It seems now to be thoroughly established by lines of trustworthy soundings which have been run in all directions, that the average depth of the ocean is a little over 2,000 fathoms." This Journal, vol. xvi, (1878), p. 351. Dr. Krümmel estimates the mean depth at 1877 fathoms. See note in Popular Science Monthly, vol. xvi, Dec. 1879, p. 287.

all the water of the globe amounts to only 335,500,000 cubic miles or but little more than three-fifths of that required to form the assumed ice-cap.

If the above estimate seems too large, let it be reduced by seven-eighths, which will bring it well within the bounds prescribed by more moderate advocates of the theory; but even then it is too large to be admissible; for it would require one-fifth of the water of the globe to form even the smaller ice-cap. But diminishing the water of the globe one-fifth would diminish the water-covered area by a considerably larger fraction; for the sea bottom does not descend uniformly to the deeper abysses. The slope is, usually, gentle for a considerable distance from the shore, and then steep and precipitous to the abyssal depths. Reducing the water one-fifth would therefore reduce the area covered by it one-third. Suppose now the ice-cap be around the south pole: The diminution caused by the removal of so much water, and the further diminution resulting from the displacement of the earth's center of gravity, would drain nearly all the water from the northern hemisphere. But the consequent stoppage of marine circulation and of the formation of aqueous vapor would, as shown in Section I, so increase the diurnal and annual thermometrical range as to render the hemisphere uninhabitable for existing organisms.

Relative mass of the two ice-caps.—Assuming the ice-field tabulated above to be of uniform thickness for five degrees on each side of the parallels given, and to extend to lat. 45°, its mean depth would be 1·356 miles. Its mass would therefore be only $\frac{1}{15}$ of the larger or little over $\frac{1}{2}$ of the smaller of the ice-caps considered in the preceding paragraphs. It should be borne in mind, too, that this is the *maximum synchronous accumulation* under more favorable conditions than would be likely to obtain in nature. The consequent displacement of the earth's center of gravity has accordingly not been computed.

Conclusion.—It seems quite safe to affirm that in any extensive polar ice-field the thickness will decrease from near the margin toward the pole, where the attenuation will be greatest. It may accordingly be concluded that a sufficient accumulation of polar ice to displace seriously the earth's center of gravity or influence the motion of middle-latitude glaciers, can never have taken place in this hemisphere.

ART. XXXIX.—*Address of Sir John Lubbock, President of the British Association at York.*

* * THE connection of the British Association with the City of York does not depend merely on the fact that our first meeting was held here. It originated in a letter addressed by Sir David Brewster to Professor Phillips, as Secretary to your York Philosophical Society, by whom the idea was warmly taken up. The first meeting was held on September 26, 1831, the chair being taken by Lord Milton, who delivered an address, after which Mr. William Vernon Harcourt, Chairman of the Committee of Management, submitted to the meeting a code of rules which had been so maturely considered, and so wisely framed, that they have remained substantially the same down to the present day.

Of those who organized and took part in that first meeting, few, alas, remain. Brewster and Phillips, Harcourt and Lord Milton, Lyell and Murchison, all have passed away, but their memories live among us. Some few, indeed, of those present at our first meeting we rejoice to see here to-day, including one of the five members constituting the original organizing Committee, our venerable Vice-President, Archdeacon Creyke.

The constitution and objects of the Association were so ably described by Mr. Spottiswoode, at Dublin, and are so well known to you, that I will not dwell on them this evening. The excellent President of the Royal Society, in the same address, suggested that the past history of the Association would form an appropriate theme for the present meeting. The history of the Association, however, is really the history of science, and I long shrunk from the attempt to give even a panoramic survey of a subject so vast and so difficult; nor should I have ventured to make any such attempt, but that I knew I could rely on the assistance of friends in every department of science.

Certainly, however, this is an opportunity on which it may be well for us to consider what have been the principal scientific results of the last half-century, dwelling especially on those with which this Association is more directly concerned, either as being the work of our own members, or as having been made known at our meetings. I have, moreover, especially taken those discoveries which the Royal Society has deemed worthy of a medal. It is of course impossible within the limits of a single address to do more than allude to a few of these, and that very briefly. In dealing with so large a subject I first hoped that I might take our annual volumes as a text-book. This, however, I at once found to be quite impossible. For instance, the first volume commences with a

Report on Astronomy by Sir G. Airy; I may be pardoned, I trust, for expressing my pleasure at finding that the second was one by my father, on the Tides, prepared, like the preceding, at the request of the Council; then comes one on Meteorology by Forbes, Radiant Heat by Baden Powell, Optics by Brewster, Mineralogy by Whewell, and so on. My best course will therefore be to take our different Sections one by one, and endeavor to bring before you a few of the principal results which have been obtained in each department.

The Biological Section is that with which I have been most intimately associated, and with which it is, perhaps, natural that I should begin.

Fifty years ago it was the general opinion that animals and plants came into existence just as we now see them. We took pleasure in their beauty; their adaptation to their habits and mode of life in many cases could not be overlooked or misunderstood. Nevertheless, the book of Nature was like some richly illuminated missal, written in an unknown tongue; the graceful forms of the letters, the beauty of the coloring, excited our wonder and admiration; but of the true meaning little was known to us; indeed we scarcely realized that there was any meaning to decipher. Now glimpses of the truth are gradually revealing themselves; we perceive that there is a reason—and in many cases we know what that reason is—for every difference in form, in size and in color; for every bone and every feather, almost for every hair. Moreover, each problem which is solved opens out vistas, as it were, of others perhaps even more interesting. With this great change the name of our illustrious countryman, Darwin, is intimately associated, and the year 1859 will always be memorable in science as having produced his great work on "The Origin of Species." In the previous year he and Wallace had published short papers, in which they clearly state the theory of natural selection, at which they had simultaneously and independently arrived. We cannot wonder that Darwin's views should have at first excited great opposition. Nevertheless from the first they met with powerful support, especially, in this country, from Hooker, Huxley and Herbert Spencer. The theory is based on four axioms:—

"1. That no two animals or plants in nature are identical in all respects.

"2. That the offspring tend to inherit the peculiarities of their parents.

"3. That of those which come into existence, only a small number reach maturity.

"4. That those, which are, on the whole, best adapted to the circumstances in which they are placed, are most likely to leave descendants."

Darwin commenced his work by discussing the causes and extent of variability in animals, and the origin of domestic varieties; he showed the impossibility of distinguishing between varieties and species, and pointed out the wide differences which man has produced in some cases—as, for instance, in our domestic pigeons, all unquestionably descended from a common stock. He dwelt on the struggle for existence (which has since become a household word), and which, inevitably resulting in the survival of the fittest, tends gradually to adapt any race of animals to the conditions in which it occurs.

While thus, however, showing the great importance of natural selection, he attributed to it no exclusive influence, but fully admitted that other causes—the use and disuse of organs, sexual selection, etc.—had to be taken into consideration. Passing on to the difficulties of his theory he accounted for the absence of intermediate varieties between species, to a great extent, by the imperfection of the geological record. Here, however, I must observe that, as I have elsewhere remarked, those who rely on the absence of links between different species really argue in a vicious circle, because wherever such links do exist they regard the whole chain as a single species. The dog and jackal, for instance, are now regarded as two species, but if a series of links were discovered between them they would be united into one. Hence in this sense there never can be links between any two species, because as soon as the links are discovered the species are united. Every variable species consists, in fact, of a number of closely connected links.

But if the geological record be imperfect, it is still very instructive. The further paleontology has progressed the more it has tended to fill up the gaps between existing groups and species, while the careful study of living forms has brought into prominence the variations dependent on food, climate, habitat, and other conditions, and shown that many species long supposed to be absolutely distinct are so closely linked together by intermediate forms that it is difficult to draw a satisfactory line between them. Thus the European and American bisons are connected by the *Bison priscus* of Prehistoric Europe; the grizzly bear and the brown bear, as Busk has shown, are apparently the modern representatives of the cave bear; Flower has pointed out the paleontological evidence of gradual modification of animal forms in the Artiodactyles; while among the Invertebrata, Carpenter and Williamson have proved that it is almost impossible to divide the Foraminifera into well-marked species; and, lastly, among plants, there are large genera, as, for instance, *Rubus* and *Hieracium*, with reference to the species of which no two botanists are agreed.

The principles of classification point also in the same direc-

tion, and are based more and more on the theory of descent. Biologists endeavor to arrange animals on what is called the "natural system." No one now places whales among fish, bats among birds, or shrews with mice, notwithstanding their external similarity; and Darwin maintained that "community of descent was the hidden bond which naturalists had been unconsciously seeking." How else, indeed, can we explain the fact that the framework of bones is so similar in the arm of a man, the wing of a bat, the fore-leg of a horse, and the fin of a porpoise—that the neck of a giraffe and that of an elephant contain the same number of vertebræ?

Strong evidence is, moreover, afforded by embryology; by the presence of rudimentary organs and transient characters, as, for instance, the existence in the calf of certain teeth which never cut the gums, the shrivelled and useless wings of some beetles, the presence of a series of arteries in the embryos of the higher Vertebrata exactly similar to those which supply the gills in fishes, even the spots on the young blackbird, the stripes on the lion's cub; these, and innumerable other facts of the same character, appear to be incompatible with the idea that each species was specially and independently created; and to prove, on the contrary, that the embryonic stages of species show us more or less clearly the structure of their ancestors.

Darwin's views, however, are still much misunderstood. I believe there are thousands who consider that according to his theory a sheep might turn into a cow, or a zebra into a horse. No one would more confidently withstand any such hypothesis, his view being, of course, not that the one could be changed into the other, but that both are descended from a common ancestor.

No one, at any rate, will question the immense impulse which Darwin has given to the study of natural history, the number of new views he has opened up, and the additional interest which he has aroused in, and contributed to, Biology. When we were young we knew that the leopard had spots, the tiger was striped, and the lion tawny: but why this was so it did not occur to us to ask; and if we had asked no one would have answered. Now we see at a glance that the stripes of the tiger have reference to its life among jungle-grasses; the lion is sandy, like the desert; while the markings of the leopard resemble spots of sunshine glancing through the leaves. Again, Wallace in his charming essays on natural selection has shown how the same philosophy may be applied even to birds' nests—how, for instance, open nests have led to the dull color of hen birds; the only British exception being the kingfisher, which, as we know, nests in river-banks. Lower still, among insects, Weismann has taught us that even the markings of

caterpillars are full of interesting lessons; while, in other cases, specially among butterflies, Bates has made known to us the curious phenomena of mimicry.

The science of embryology may almost be said to have been created in the last half-century. Fifty years ago it was a very general opinion that animals which are unlike when mature, were dissimilar from the beginning. It is to Von Baer, the discoverer of the mammalian ovum, that we owe the great generalization that the development of the egg is in the main a progress from the general to the special, that zoological affinity is the expression of similarity of development, and that the different great types of animal structure are the result of different modes of development—in fact, that embryology is the key to the laws of animal development.

Thus the young of existing species resemble in many cases the mature forms which flourished in ancient times. Huxley has traced up the genealogy of the horse to the Miocene Anchitherium, and his views have since been remarkably confirmed by Marsh's discovery of the Pliohippus, Protohippus, Miohippus and Mesohippus, leading down from the Eohippus of the early Tertiary strata. In the same way Gaudry has called attention to the fact that just as the individual stag gradually acquires more and more complex antlers: having at first only a single prong, in the next year two points, in the following three, and so on; so the genus, as a whole, in Middle Miocene times, had two pronged horns; in the Upper Miocene, three; and that it is not till the Upper Pliocene that we find any species with the magnificent antlers of our modern deer. It seems to be now generally admitted that birds have come down to us through the Dinosaurians, and, as Huxley has shown, the profound break once supposed to exist between birds and reptiles has been bridged over by the discovery of reptilian birds and bird-like reptiles; so that, in fact, birds are modified reptiles. Again, the remarkable genus Peripatus, so well studied by Moseley, tends to connect the annulose and articulate types. Again, the structural resemblances between Amphioxus and the Ascidians had been pointed out by Goodsir; and Kowalevsky in 1866 showed that these were not mere analogies, but indicated a real affinity. These observations, in the words of Allen Thomson, "have produced a change little short of revolutionary in embryological and zoological views, leading as they do to the support of the hypothesis that the Ascidian is an earlier stage in the phylogenetic history of the mammal and other vertebrates."

The larval forms which occur in so many groups, and of which the Insects afford us the most familiar examples, are, in the words of Quatrefages, embryos, which lead an independent

life. In such cases as these external conditions act upon the larvæ as they do upon the mature form; hence we have two classes of changes, adaptational or adaptive, and developmental. These and many other facts must be taken into consideration; nevertheless naturalists are now generally agreed that embryological characters are of high value as guides in classification, and, it may, I think, be regarded as well-established that, just as the contents and sequence of rocks teach us the past history of the earth, so is the gradual development of the species indicated b the structure of the embryo and its developmental changes.

When the supporters of Darwin are told that his theory is incredible, they may fairly ask why it is impossible that a species in the course of hundreds of thousands of years should have passed through changes which occupy only a few days or weeks in the life-history of each individual?

The phenomena of yolk-segmentation, first observed by Prevost and Dumas, are now known to be in some form or other invariably the precursors of embryonic development; while they reproduce, as the first stages in the formation of the higher animals, the main and essential features in the life-history of the lowest forms. The "blastoderm" as it is called, or first germ of the embryo in the egg, divides itself into two layers, corresponding, as Huxley has shown, to the two layers into which the body of the Cœlenterata may be divided. Not only so, but most embryos at an early stage of development have the form of a cup, the walls of which are formed by the two layers of the blastoderm. Kowalevsky was the first to show the prevalence of this embryonic form, and subsequently Lankester and Hæckel put forward the hypothesis that it was the embryonic repetition of an ancestral type, from which all the higher forms are descended. The cavity of the cup is supposed to be the stomach of this simple organism, and the opening of the cup the mouth. The inner layer of the wall of the cup constitutes the digestive membrane, and the outer the skin. To this form Hæckel gave the name Gastræa. It is, perhaps, doubtful whether the theory of Lankester and Hæckel can be accepted in precisely the form they propounded it; but it has had an important influence on the progress of embryology. I cannot quit the science of embryology without alluding to the very admirable work on "Comparative Embryology" by our new general secretary, Mr. Balfour, and also the "Elements of Embryology" which he had previously published in conjunction with Dr. M. Foster.

In 1842, Steenstrup published his celebrated work on the "Alternation of Generations," in which he showed that many species are represented by two perfectly distinct types or

broods, differing in form, structure and habits; that in one of them males are entirely wanting, and that the reproduction is effected by fission, or by buds, which, however, are in some cases structurally indistinguishable from eggs. Steenstrup's illustrations were mainly taken from marine or parasitic species, of very great interest, but not generally familiar, excepting to naturalists. It has since been shown that the common Cynips or Gallfly is also a case in point. It had long been known that in some genera belonging to this group, males are entirely wanting, and it has now been shown by Bassett, and more thoroughly by Adler, that some of these species are double-brooded; the two broods having been considered as distinct genera.

Thus an insect known as *Neuroterus lenticularis*, of which females only occur, produces the familiar oak-spangles so common on the under sides of oak leaves, from which emerge, not *Neuroterus lenticularis*, but an insect hitherto considered as a distinct species, belonging even to a different genus, *Spathegaster baccarum*. In Spathegaster both sexes occur; they produce the currant-like galls found on oaks, and from these galls Neuroterus is again developed. So also the King Charles oak-apples produce a species known as *Teras terminalis*, which descends to the ground, and makes small galls on the roots of the oak. From these emerge an insect known as *Biorhiza aptera*, which again gives rise to the common oak-apple.

It might seem that such enquiries as these could hardly have any practical bearing. Yet it is not improbable that they may lead to very important results. For instance, it would appear that the fluke which produces the rot in sheep, passes one phase of its existence in the black slug, and we are not without hopes that the researches, in which our lamented friend Professor Rolleston was engaged at the time of his death, which we all so much deplore, will lead, if not to the extirpation, at any rate to the diminution, of a pest from which our farmers have so grievously suffered. It was in the year 1839 that Schwann and Schleiden demonstrated the intimate relation in which animals and plants stand to each other, by showing the identity of the laws of development of the elementary parts in the two kingdoms of organic nature. Analogies indeed had been previously pointed out, the presence of cellular tissue in certain parts of animals was known, but Caspar F. Wolff's brilliant memoir had been nearly forgotten; and the tendency of microscopical investigation had rather been to encourage the belief that no real similarity existed; that the cellular tissue of animals was essentially different from that of plants. This had arisen chiefly, perhaps, because fully formed tissues were compared, and it was mainly the study of the growth of cells

which led to the demonstration of the general law of development for all organic elementary tissues.

As regards descriptive biology, by far the greater number of species now recorded have been named and described within the last half-century, and it is not too much to say that not a day passes without adding new species to our lists. A comparison, for instance, of the edition of Cuvier's "Regne Animal," published in 1828, as compared with the present state of our knowledge, is most striking.

Dr. Günther has been good enough to make a calculation for me. The numbers, of course, are only approximate, but it appears that while the total number of animals described up to 1831 was not more than 70,000, the number now is at least 320,000.

Lastly, to show how large a field still remains for exploration, I may add that Mr. Waterhouse estimates that the British Museum alone contains not fewer than 12,000 species of insects which have not yet been described, while our collections do not probably contain anything like one-half of those actually in existence. Further than this, the anatomy and habits even of those which have been described offer an inexhaustible field for research, and it is not going too far to say that there is not a single species which would not amply repay the devotion of a lifetime.

One remarkable feature in the modern progress of biological science has been the application of improved methods of observation and experiment; and the employment in physiological research of the exact measurements employed by the experimental physicist. Our microscopes have been greatly improved: achromatic object-glasses were introduced by Lister in 1829; the binocular arrangement by Wenham in 1856; while immersion lenses, first suggested by Amici, and since carried out under the formula of Abbe, are most valuable. The use of chemical reagents in microscopical investigations has proved most instructive, and another very important method of investigation has been the power of obtaining very thin slices by imbedding the object to be examined in paraffin or some other soft substance. In this manner we can now obtain, say, fifty separate sections of the egg of a beetle, or the brain of a bee.

At the close of the last century, Sprengel published a most suggestive work on flowers, in which he pointed out the curious relation existing between these and insects, and showed that the latter carried the pollen from flower to flower. His observations, however, attracted little notice, until Darwin called attention to the subject in 1862. It had long been known that the cowslip and primrose exist under two forms, about equally numerous, and differing from one another in the arrangements

of their stamens and pistils; the one form having the stamens on the summit of the flower and the stigma half-way down; while in the other the relative positions are reversed, the stigma being at the summit of the tube, and the stamens half-way down. This difference had, however, been regarded as a case of mere variability; but Darwin showed it to be a beautiful provision, the result of which is that insects fertilize each flower with pollen brought from a different plant; and he proved that flowers fertilized with pollen from the other form yield more seed than if fertilized with pollen from the same form, even if taken from a different plant.

Attention having been thus directed to the question, an astonishing variety of most beautiful contrivances have been observed and described by many botanists, especially Hooker, Axel, Delpino, Hildebrand, Bennet, Fritz Müller, and above all Herman Müller and Darwin himself. The general result is that to insects, and especially to bees, we owe the beauty of our gardens, the sweetness of our fields. To their beneficent, though unconscious action, flowers owe their scent and color, their honey — nay, in many cases, even their form. Their present shape and varied arrangements, their brilliant colors, their honey, and their sweet scent are all due to the selection exercised by insects.

In these cases, the relation between plants and insects is one of mutual advantage. In many species, however, plants present us with complex arrangements adapted to protect them from insects: such, for instance, are in many cases, the resinous glands which render leaves unpalatable; the thickets of hairs and other precautions which prevent flowers from being robbed of their honey by ants. Again, more than a century ago, our countryman, Ellis, described an American plant, Dionæa, in which the leaves are somewhat concave, with long lateral spines and a joint in the middle; close up with a jerk, like a rat-trap, the moment any unwary insect alights on them. The plant, in fact, actually captures and devours insects. This observation also remained as an isolated fact until within the last few years, when Darwin, Hooker, and others have shown that many other species have curious and very varied contrivances for supplying themselves with animal food.

As regards the progress of botany in other directions, Mr. Thiselton Dyer has been kind enough to assist me in endeavoring to place the principal facts before you. Some of the most fascinating branches of botany — morphology, histology, and physiology scarcely existed before 1833. In the two former branches, the discoveries of von Mohl are preëminent. He first observed cell-division in 1835, and detected the presence of starch in chlorophyll-corpuscles in 1837, while he first

described protoplasm, now so familiar to us, at least by name, in 1846. In the same year Amici discovered the existence of the embryonic vesicle in the embryo sac, which develops into the embryo when fertilized by the entrance of the pollen-tube into the micropyle. The existence of sexual reproduction in the lower plants was doubtful, or at least doubted by some eminent authorities, as recently as 1853, when the actual process of fertilization in the common bladderwrack of our shores was observed by Thuret, while the reproduction of the larger fungi was first worked out by De Bary in 1863.

As regards lichens, Schwendener proposed, in 1869, the startling theory, now, however, accepted by some of the highest authorities, that lichens are not autonomous organisms, but commensal associations of a fungus parasitic on an alga. With reference to the higher Cryptogams it is hardly too much to say that the whole of our exact knowledge of their life-history has been obtained during the last half-century. Thus in the case of ferns the male organs, or antheridia, were first discovered by Nägeli in 1844, and the archegonia, or female organs, by Saminski, in 1848. The early stages in the development of mosses were worked out by Valentine in 1833. Lastly, the principle of Alternation of Generations in plants was discovered by Hofmeister. This eminent naturalist also, in 1851–4, pointed out the homologies of the reproductive processes in mosses, vascular cryptogams, gymnosperms, and angiosperms.

Geographical Botany can hardly be said to have had any scientific status anterior to the publication of the "Origin of Species." The way had been paved, however, by A. de Candolle and the well-known essay of Edward Forbes — "On the Distribution of the Plants and Animals of the British Isles,"— by Sir J. Hooker's introductory essay to the "Flora of New Zealand," and by Hooker and Thomson's introductory essay to the "Flora Indica." One result of these researches has been to give the *coup-de-grâce* to the theory of an Atlantis. Lastly, in a lecture delivered to the Geographical Society in 1878, Thiselton Dyer himself has summed up the present state of the subject, and contributed an important addition to our knowledge of plant-distribution by showing how its main features may be explained by migration in longitude from north to south without recourse being had to a submerged southern continent for explaining the features common to South Africa, Australia and America.

The fact that systematic and geographical botany have claimed a preponderating share of the attention of British phytologists, is no doubt in great measure due to the ever-expanding area of the British Empire, and the rich botanical treasures which

we are continually receiving from India and our numerous colonies. The series of Indian and Colonial Floras, published under the direction of the authorities at Kew, and the "Genera Plantarum" of Bentham and Hooker, are certainly an honor to our country. To similar causes we may trace the rise and rapid progress of economic botany, to which the late Sir W. Hooker so greatly contributed.

In vegetable physiology some of the most striking researches have been on the effect produced by rays of light of different refrangibility. Daubeny, Draper and Sachs have shown that the light of the red end of the spectrum is more effective than that of the blue, so far as the decomposition of carbon dioxide (carbonic acid) is concerned.

Nothing could have appeared less likely than that researches into the theory of spontaneous generation should have led to practical improvements in medical science. Yet such has been the case. Only a few years ago Bacteria seemed mere scientific curiosities. It had long been known that an infusion — say, of hay — would, if exposed to the atmosphere, be found, after a certain time, to teem with living forms. Even those few who still believe that life would be spontaneously generated in such an infusion, will admit that these minute organisms are, if not entirely, yet mainly, derived from germs floating in our atmosphere; and if precautions are taken to exclude such germs, as in the careful experiments especially of Pasteur, Tyndall, and Roberts, every one will grant that in ninety-nine cases out of a hundred no such development of life will take place. In 1836–7 Cagniard de la Tour and Schwann independently showed that fermentation was no mere chemical process, but was due to the presence of a microscopic plant. But, more than this, it has been gradually established that putrefaction is also the work of microscopic organisms.

These facts have led to most important results in Surgery. One reason why compound fractures are so dangerous, is because, the skin being broken, the air obtains access to the wound, bringing with it innumerable germs, which too often set up putrefying action. Lister first made a practical application of these observations. He set himself to find some substance capable of killing the germs without being itself too potent a caustic, and he found that dilute carbolic acid fulfilled these conditions. This discovery has enabled many operations to be performed which would previously have been almost hopeless.

The same idea seems destined to prove as useful in Medicine as in Surgery. There is great reason to suppose that many diseases, especially those of a zymotic character, have their origin in the germs of special organisms. We know that fever runs a

certain definite course. The parasitic organisms are at first few, but gradually multiply at the expense of the patient, and then die out again. Indeed, it seems to be thoroughly established that many diseases are due to the excessive multiplication of microscopic organisms, and we are not without hope that means will be discovered by which, without injury to the patient, these terrible, though minute, enemies may be destroyed, and the disease thus stayed. *Bacillus anthracis*, for instance, is now known to be the cause of splenic fever, which is so fatal to cattle, and is also communicable to man. At Bradford, for instance, it is only too well-known as the woolsorter's disease. If, however, matter containing the Bacillus be treated in a particular manner, and cattle be then inoculated with it, they are found to acquire an immunity from the fever. The interesting researches of Burdon Sanderson, Greenfield, Koch, Pasteur, Toussaint, and others, seem to justify the hope that we may be able to modify these and other germs, and then by appropriate inoculation to protect ourselves against fever and other acute diseases.

The history of Anæsthetics is a most remarkable illustration how long we may be on the very verge of a most important discovery. Ether, which, as we all know, produces perfect insensibility to pain, was discovered as long ago as 1540. The anæsthetic property of nitrous oxide, now so extensively used, was observed in 1800 by Sir H. Davy, who actually experimented on himself, and had one of his teeth painlessly extracted when under its influence. He even suggests that "as nitrous oxide gas seems capable of destroying pain, it could probably be used with advantage in surgical operations." Nay, this property of nitrous oxide was habitually explained and illustrated in the chemical lectures given in hospitals, and yet for fifty years the gas was never used in actual operations. No one did more to promote the use of anæsthetics than Sir James Y. Simpson, who introduced chloroform, a substance which was discovered in 1831, and which for a while almost entirely superseded ether and nitrous oxide, though, with improved methods of administration, the latter are now coming into favor again.

The only other reference to Physiology which time permits me to make, is the great discovery of the reflex action, as it is called, of the nervous centres. Reflex actions had been long ago observed, and it was known that they were more or less independent of volition. But the general opinion was that these movements indicated some feeble power of sensation independently of the brain, and it was not till the year 1832 that the "reflex action" of certain nervous centres was made known to us by Marshall Hall, and almost at the same period by Johannes Müller.

Few branches of science have made more rapid progress in the last half-century than that which deals with the ancient condition of man. When our Association was founded it was generally considered that the human race suddenly appeared on the scene, about 6,000 years ago, after the disappearance of the extinct mammalia, and when Europe, both as regards physical conditions and the other animals by which it was inhabited, was pretty much in the same condition as in the period covered by Greek and Roman history. Since then the persevering researches of Layard, Rawlinson, Botta and others have made known to us, not only the statutes and palaces of the ancient Assyrian monarch, but even their libraries; the cuneiform characters have been deciphered, and we can not only see, but read in the British Museum, the actual contemporary records, on burnt clay cylinders, of the events recorded in the historical books of the Old Testament and in the pages of Herodotus. The researches in Egypt also seem to have satisfactorily established the fact that the pyramids themselves are at least 6,000 years old, while it is obvious that the Assyrian and Egyptian monarchies cannot suddenly have attained to the wealth and power, the state of social organization, and progress in the arts, of which we have before us, preserved by the sand of the desert from the ravages of man, such wonderful proofs.

In Europe, the writings of the earliest historians and poets indicated that, before iron came into general use, there was a time when bronze was the ordinary material of weapons, axes, and other cutting implements, and though it seemed *à priori* improbable that a compound of copper and tin should have preceded the simple metal iron, nevertheless the researches of archæologists have shown that there really was in Europe a "Bronze Age," which at the dawn of history was just giving way to that of "Iron."

The contents of ancient graves, buried in many cases so that their owner might carry some at least of his wealth with him to the world of spirits, have proved very instructive. More especially the results obtained by Nilsson in Scandinavia, by Hoare and Borlase, Bateman and Greenwell, in our own country, and the contents of the rich cemetery at Hallstadt, left no room for doubt as to the existence of a Bronze Age; but we get a completer idea of the condition of Man at this period from the Swiss lake-villages, first made known to us by Keller, and subsequently studied by Morlot, Troyon, Desor, Rütimeyer, Heer, and other Swiss archæologists. Along the shallow edges of the Swiss lakes there flourished, once upon a time, many populous villages or towns, built on platforms supported by piles, exactly as many Malayan villages are now. Under these circumstances innumerable objects were one by one dropped

into the water; sometimes whole villages were burnt, and their contents submerged; and thus we have been able to recover, from the waters of oblivion in which they had rested for more than 2,000 years, not only the arms and tools of this ancient people, the bones of their animals, their pottery and ornaments, but the stuffs they wore, the grain they had stored up for future use, even fruits and cakes of bread.

But this bronze-using people were not the earliest occupants of Europe. The contents of ancient tombs give evidence of a time when metal was unknown. This also was confirmed by the evidence then unexpectedly received from the Swiss lakes. By the side of the bronze-age villages were others, not less extensive, in which, while implements of stone and bone were discovered literally by thousands, not a trace of metal was met with. The shell-mounds or refuse-heaps accumulated by the ancient fishermen along the shores of Denmark, and carefully examined by Steenstrup, Worsaae, and other Danish naturalists, fully confirmed the existence of a "Stone Age."

We have still much to learn, I need hardly say, about this Stone-age people, but it is surprising how much has been made out. Evans truly observes, in his admirable work on "Ancient Stone Implements," "that so far as external appliances are concerned, they are almost as fully represented as would be those of any existing savage nation by the researches of a painstaking traveler." We have their axes, adzes, chisels, borers, scrapers, and various other tools, and we know how they made and how they used them; we have their personal ornaments and implements of war; we have their cooking utensils; we know what they ate and what they wore; lastly, we know their mode of sepulture and funeral customs. They hunted the deer and horse, the bison and urus, the bear and the wolf, but the reindeer had already retreated to the North.

No bones of the reindeer, no fragment of any of the extinct mammalia, have been found in any of the Swiss lake-villages or in any of the thousands of the tumuli which have been opened in our own country or in Central and Southern Europe. Yet the contents of caves and of river-gravels afford abundant evidence that there was a time when the mammoth and rhinoceros, the musk-ox and reindeer, the cave lion and hyena, the great bear and the gigantic Irish elk wandered in our woods and valleys, and the hippopotamus floated in our rivers; when England and France were united, and the Thames and the Rhine had a common estuary. This was long supposed to be before the advent of man. At length, however, the discoveries of Boucher de Perthes in the valley of the Somme, supported as they are by the researches of many continental naturalists, and in our own country of MacEnery and Godwin-Austen, Prestwich

and Lyell, Vivian and Pengelly, Christy, Evans and many more, have proved that man formed a humble part of this strange assembly.

Nay, even at this early period there were at least two distinct races of men in Europe; one of them — as Boyd Dawkins has pointed out — closely resembling the modern Esquimaux in form, in his weapons and implements, probably in his clothing, as well as in so many of the animals with which he was associated.

At this stage Man appears to have been ignorant of pottery, to have had no knowledge of agriculture, no domestic animals, except perhaps the dog. His weapons were the axe, the spear, and the javelin; I do not believe he knew the use of the bow, though he was probably acquainted with the lance. He was, of course, ignorant of metal, and his stone implements, though skilfully formed, were of quite different shapes from those of the second Stone age, and were never ground. This earlier Stone period, when man coëxisted with these extinct mammalia, is known as Palæolithic, or Early Stone Age, in opposition to the Neolithic, or Newer Stone Age.

The remains of the mammalia which coëxisted with man in pre-historic times have been most carefully studied by Owen, Lartet, Rütimeyer, Falconer, Busk, Boyd-Dawkins, and others. The presence of the mammoth, the reindeer, and especially of the musk-ox, indicates a severe, not to say an arctic, climate, the existence of which, moreover, was proved by other considerations; while, on the contrary, the hippopotamus requires considerable warmth. How then is this association to be explained?

While the climate of the globe is, no doubt, much affected by geographical conditions, the cold of the glacial period was, I believe, mainly due to the eccentricity of the earth's orbit combined with the obliquity of the ecliptic. The result of the latter condition is a period of 21,000 years, during one-half of which the northern hemisphere is warmer than the southern, while during the other 10,500 years the reverse is the case. At present we are in the former phase, and there is, we know, a vast accumulation of ice at the south pole. But when the earth's orbit is nearly circular, as it is at present, the difference between the two hemispheres is not very great; on the contrary, as the eccentricity of the orbit increases the contrast between them increases also. This eccentricity is continually oscillating between certain limits, which Croll and subsequently Stone have calculated out for the last million years. At present the eccentricity is ·016 and the mean temperature of the coldest month in London is about 40°. Such has been the state of things for nearly 100,000 years;

but before that there was a period, beginning 300,000 years ago, when the eccentricity of the orbit varied from ·26 to ·57. The result of this would be greatly to increase the effect due to the obliquity of the orbit; at certain periods the climate would be much warmer than at present, while at others the number of days in winter would be twenty more, and of summer twenty less than now, while the mean temperature of the coldest month would be lowered 20°. We thus get something like a date for the last glacial epoch, and we see that it was not simply a period of cold, but rather one of extremes, each beat of the pendulum of temperature lasting for no less than 21,000 years. This explains the fact that, as Morlot showed in 1854, the glacial deposits of Switzerland, and, as we now know, those of Scotland, are not a single uniform layer, but a succession of strata, indicating very different conditions. I agree also with Croll and Geikie in thinking that these considerations explain the apparent anomaly of the coëxistence in the same gravels of arctic and tropical animals; the former having lived in the cold, while the latter flourished in the hot, periods.

It is, I think, now well established that man inhabited Europe during the milder periods of the glacial epoch. Some high authorities, indeed, consider that we have evidence of his presence in pre-glacial and even in Miocene times, but I confess that I am not satisfied on this point. Even the more recent period carries back the record of man's existence to a distance so great as altogether to change our views of ancient history.

Nor is it only as regards the antiquity and material condition of man in prehistoric times that great progress has been made. If time permitted, I should have been glad to have dwelt on the origin and development of language, of custom, and of law. On all of these the comparison of the various lower races still inhabiting so large a portion of the earth's surface, has thrown much light; while even in the most cultivated nations we find survivals, curious fancies, and lingering ideas; the fossil remains, as it were, of former customs and religions embedded in our modern civilization, like the relics of extinct animals in the crust of the earth.

In geology the formation of our Association coincided with the appearance of Lyell's "Principles of Geology," the first volume of which was published in 1830 and the second in 1832. At that time the received opinion was that the phenomena of Geology could only be explained by violent periodical convulsions, and a high intensity of terrestrial energy culminating in repeated catastrophes. Hutton and Playfair had indeed main-

tained that such causes as those now in operation, would, if only time enough were allowed, account for the geological structure of the earth; nevertheless the opposite view generally prevailed, until Lyell, with rare sagacity and great eloquence, with a wealth of illustration and most powerful reasoning, convinced geologists that the forces now in action are powerful enough, if only time be given, to produce results quite as stupendous as those which Science records.

As regards stratigraphical geology, at the time of the first meeting of the British Association at York, the strata between the carboniferous limestone and the chalk had been mainly reduced to order and classified, chiefly through the labors of William Smith. But the classification of all the strata lying above the chalk and below the carboniferous limestone respectively, remained in a state of the greatest confusion. The year 1831 marks the period of the commencement of the joint labors of Sedgwick and Murchison, which resulted in the establishment of the Cambrian, Silurian, and Devonian systems. Our Pre-Cambrian strata have recently been divided by Hicks into four great groups of immense thickness, and implying, therefore, a great lapse of time; but no fossils have yet been discovered in them. Lyell's classification of the Tertiary deposits; the result of the studies which he carried on with the assistance of Deshayes and others, was published in the third volume of the "Principles of Geology" in 1833. The establishment of Lyell's divisions of Eocene, Miocene and Pliocene, was the starting-point of a most important series of investigations by Prestwich and others of these younger deposits; as well as of the Post-tertiary, Quaternary, or drift beds, which are of special interest from the light they have thrown on the early history of man.

A full and admirable account of what has recently been accomplished in this department of science, especially as regards the paleozoic rocks, will be found in Etheridge's late address to the Geological Society.

Before 1831 the only geological maps of this country were William Smith's general and county maps, published between the years 1815 and 1824. In the year 1832 De la Beche made proposals to the Board of Ordnance to color the ordnance-maps geologically, and a sum of 300*l.* was granted for the purpose. Out of this small beginning grew the important work of the Geological Survey.

The cause of slaty cleavage had long been one of the great difficulties of geology. Sedgwick suggested that it was produced by the action of crystalline or polar forces. According to this view miles and miles of country, comprising great mountain masses, were neither more nor less than parts of a gigantic

crystal. Sharpe, however, called attention to the fact that shells and other fossils contained in slate rocks are compressed in a direction at right angles to the planes of cleavage, as if the rocks had been seized in the jaws of a gigantic vise. Sorby first maintained that the cleavage itself was due to pressure. He observed slate rocks containing small plates of mica, and that the effect of pressure would tend to arrange these plates with their flat surfaces perpendicular to the direction of the pressure. Tyndall has since shown that the presence of flat flakes is not necessary. He proved by experiment that pure wax could be made by pressure to split into pieces of great tinuity, which he attributes mainly to the lateral sliding of the particles of the wax over each other; and thus the result of pressure on such a mass is to develop a fissile structure similar to that produced in wax on a small scale, or on a great one in the slate rocks of Cumberland or Wales.

The difficult problem of the conditions under which granite and certain other rocks were formed was attacked by Sorby with great skill in a paper read before the Geological Society in 1858. The microscopic hollows in many minerals contain a liquid which does not entirely fill the hollow, but leaves a small vacuum; and Sorby ingeniously pointed out that the rock must have solidified at least at a temperature high enough to expand the liquid so as to fill the cavity. Sorby's important memoir laid the foundation of microscopic petrography, which is now not only one of the most promising branches of geological research, but which has been successfully applied by Sorby himself, and by Maskelyne, to the study of meteorites.

As regards the physical character of the earth, two theories have been held: one, that of a fluid interior covered by a thin crust; the other, of a practically solid sphere. The former is now very generally admitted, both by astronomers and geologists, to be untenable. The prevailing feeling of geologists on this subject has been well expressed by Professor LeConte, who says, "the whole theory of igneous agencies—which is little less than the whole foundation of theoretic geology—must be reconstructed on the basis of a solid earth."

In 1837 Agassiz startled the scientific world by his "Discours sur l'ancienne extension des Glaciers," in which, developing the observation already made by Charpentier and Venetz, that bowlders had been transported to great distances, and that rocks far away from, or high above, existing glaciers, are polished and scratched by the action of ice, he boldly asserted the existence of a "glacial period," during which Switzerland the North of Europe were subjected to great cold and buried under a vast sheet of ice.

The ancient poets described certain gifted mortals as privi-

leged to descend into the interior of the earth, and have exercised their imagination in recounting the wonders there revealed. As in other cases, however, the realities of science have proved more varied and surprising than the dreams of fiction. Of the gigantic and extraordinary animals thus revealed to us by far the greatest number have been described during the period now under review. For instance, the gigantic Cetiosaurus was described by Owen in 1838, the Dinornis of New Zealand by the same distinguished naturalist in 1839, the Mylodon in the same year, and the Archæopteryx in 1862.

In America, a large number of remarkable forms have been described, mainly by Marsh, Leidy and Cope. Marsh has made known to us the Titanosaurus, of the American (Colorado) Jurassic beds, which is, perhaps, the largest land animal yet known, being a hundred feet in length, and at least thirty in height, though it seems possible that even these vast dimensions were exceeded by those of the Atlantosaurus. Nor must I omit the Hesperornis, described by Marsh in 1872, as a carnivorous, swimming ostrich, provided with teeth, which he regards as a character inherited from reptilian ancestors; the Ichthyornis, stranger still, with biconcave vertebræ, like those of fishes, and teeth set in sockets; while in the Eocene deposits in the Rocky Mountains the same indefatigable paleontologist, among other very interesting remains, has discovered three new groups of remarkable mammals, the Dinocerata, Tillodontia, and Brontotheridæ. He has also described a number of small, but very interesting, Jurassic mammalia, closely related to those found in our Stonesfield Slate and Purbeck beds, for which he has proposed a new order, "Prototheria." Lastly, I may mention the curiously anomalous Reptilia from South Africa, which have been made known to us by Professor Owen.

Another important result of recent paleontological research is the law of brain-growth. It is not only in the higher mammalia that we find forms with brains much larger than any existing, say, in Miocene times. The rule is almost general that — as Marsh has briefly stated it — "all tertiary animals had small brains." We may even carry the generalization further. The Cretaceous birds had brains one-third smaller than those of our own day, and the brain-cavities of the Dinosauria of the Jurassic period, are much smaller than in any existing reptiles.

As giving, in a few words, an idea of the rapid progress in this department, I may mention that Morris's "Catalogue of British Fossils," published in 1843, contained 5,300 species; while that now in preparation by Mr. Etheridge enumerates 15,000.

But if these figures show how rapid our recent progress has been, they also very forcibly illustrate the imperfection of the geological record, and give us, I will not say a measure, but an idea, of the imperfection of the geological record. The number of all the described recent species is over 300,000, but certainly not half are yet on our lists, and we may safely take the total number of recent species as being not less than 700,000. But in former times there have been at the very least twelve periods, in each of which by far the greater number of species were distinct. True the number of species was probably not so large in the earlier periods as at present; but if we make a liberal allowance for this, we shall have a total of more than 2,000,000 species, of which about 25,000 only are as yet upon record; and many of these are only represented by a few, some only by a single specimen, or even only by a fragment.

The progress of paleontology may also be marked by the extent to which the existence of groups has been, if I may so say, carried back in time. Thus I believe that in 1830 the earliest known quadrupeds were small marsupials belonging to the Stonesfield slates; the most ancient mammal now known is Microlestes antiquus from the Keuper of Würtemberg; the oldest bird known in 1831 belonged to the period of the London Clay, the oldest now known is the Archæopteryx of the Solenhofen slates, though it is probable that some at any rate of the footsteps on the Triassic rocks are those of birds. So again the Amphibia have been carried back from the Trias to Coal-measures; Fish from the Old Red Sandstone to the Upper Silurian; Reptiles to the Trias; Insects from the Cretaceous to the Devonian; Mollusca and Crustacea from the Silurian to the Lower Cambrian. The rocks below the Cambrian, though of immense thickness, have afforded no relics of animal life, if we except the problematical Eozoon Canadense, so ably studied by Dawson and Carpenter. But if paleontology as yet throws no light on the original forms of life, we must remember that the simplest and the lowest organisms are so soft and perishable that they would leave "not a wrack behind." I will not, however, enlarge on this branch of science, because we shall have the advantage on Friday of hearing it treated with the skill of a master.

Passing the Science of Geography, Mr. Clements Markham has recently published an excellent summary of what has been accomplished during the half-century.

As regards the Arctic regions, in the year 1830 the coast line of Arctic America was only very partially known, the region between Barrow Strait and the continent, for instance,

being quite unexplored, while the eastern sides of Greenland and Spitzbergen, and the coasts of Nova Zembla were almost unknown. Now the whole coast of Arctic America has been delineated, the remarkable archipelago to the north has been explored, and no less than seven northwest passages — none of them, however, of any practical value — have been traced. The northeastern passage, on the other hand, so far at least as the mouths of the great Siberian rivers, may perhaps hereafter prove of commercial importance. In the Antarctic regions, Enderby and Graham Lands were discovered in 1831–2, Balleny Islands and Sabrina Land in 1839, while the fact of the existence of the great southern continent was established in 1841 by Sir James Ross, who penetrated in 1842 to 78° 11′, the southernmost point ever reached.

In Asia, to quote from Mr. Markham, "our officers have mapped the whole of Persia and Afghanistan, surveyed Mesopotamia, and explored the Pamir steppe. Japan, Borneo, Siam, the Malay peninsula, and the greater part of China have been brought more completely to our knowledge. Eastern Turkestan has been visited, and trained native explorers have penetrated to the remotest fountains of the Oxus, and the wild plateaus of Tibet. Over the northern half of the Asiatic Continent the Russians have displayed great activity. They have traversed the wild steppes and deserts of what on old atlases was called Independent Tartary, have surveyed the courses of the Jaxartes, the Oxus and the Amur, and have navigated the Caspian and the Sea of Aral. They have pushed their scientific investigations into the Pamir and Eastern Turkestan, until at last the British and Russian surveys have been connected."

Again, fifty years ago the vast Central Regions of Africa were almost a blank upon our best maps. The rudely drawn lakes and rivers in maps of a more ancient date had become discredited. They did not agree among themselves, the evidence upon which they were laid down could not be found, they were in many respects highly improbable, and they seemed inconsistent with what had then been ascertained concerning the Niger and the Blue and White Niles. At the date of which I speak, the Sahara had been crossed by English travelers from the shore of the Mediterranean: but the southern desert still formed a bar to travelers from the Cape, while the accounts of traders and others who alone had entered the country from the eastern and western coasts were considered to form an insufficient basis for a map.

Since that time the successful crossing of the Kalahari desert to Lake Ngami has been the prelude to an era of African discovery. Livingston explored the basin of the Zambesi, and

discovered vast lakes and waters which have proved to be those of the higher Congo. Burton and Speke opened the way from the West Coast, which Speke and Grant pursued into and down the Nile, and Stanley down the course of the middle and lower Congo; and the vast extension of Egyptian dominion has brought a huge slice of equatorial Africa within the limits of semi-civilization. The western side of Africa has been attacked at many points. Alexander and Galton were among the first to make known to us its western tropical regions immediately to the north of the Cape Colony; the Ogowé has been explored; the Congo promises to become a center of trade, and the navigable portions of the Niger, the Gambia, and the Senegal are familiarly known.

The progress of discovery in Australia has been as remarkable as that in Africa. The interior of this great continent was absolutely unknown to us fifty years ago, but is now crossed through its center by the electric telegraph, and no inconsiderable portion of it is turned into sheep-farms. It is an interesting fact that General Sabine, so long one of our most active officers, and who is still with us, though, unfortunately, his health has for some time prevented him from attending our meetings, was born on the very day that the first settler landed in Australia.

[To be continued.]

ART. XL.—*Notes on Earthquakes;* by C. G. ROCKWOOD.

The Scio Earthquake.—In April last the Island of Scio and its vicinity were shaken by an earthquake which caused great loss of life and property and proved to be the beginning of quite an extended series of shocks. This Island lies off the Gulf of Smyrna in the Grecian Archipelago and is about thirty-two miles long north and south, by about eighteen miles wide. It is separated from the mainland by a strait seven or eight miles wide and had about 50,000 inhabitants. The first and most violent shock occurred at 1.40 P. M. on Sunday, April 3d, and lasted ten seconds. It was followed by a second at 2 P. M. and a third at 3 P. M. of the same day. The ground was then quiet until sunset, when the shaking recommenced and continued with such frequency that up to April 5th two hundred and fifty shocks had been counted; of which thirty or forty were of sufficient strength to overthrow walls. Other shocks, often severe, occurred from time to time up to May 20th. An especially severe one, lasting four seconds, occurred on April 11th. The violent shocks with which the disturbance

began, destroyed many villages, and especially damaged the city of Scio or Kastro, on the east coast, the chief town of the island. It was estimated that in all the southern part of the island certainly nine-tenths of the houses would have to be rebuilt and some whole villages were reduced to simple masses of ruins. The loss of life was at first estimated as high as 10,000, but later advices render it probable that not more than 3000 or 4000 were killed. The consequent suffering and destitution were, however, so great that contributions were made in various countries of Europe and America for the relief of the survivors. The center of disturbance appears to have been under the eastern part of the island and the vibrations were felt with destructive effect at Tchisme and at Smyrna on the mainland to the eastward, and Eubœa and the islands of Tinos and Syra to the westward. The direction of vibration was east and west, as is shown not only by numerous personal reports, but by the direction of the cracks in the broken walls.

Die Vulkanischen Ereignisse des Jahres 1880.—The *Sixteenth Annual Report* of Dr. C. W. C. FUCHS (Mineralog. u. Petrograph. Mittheil., Wien.) is at hand and presents some points of interest.

The volcanic activity of the year was less than usual, no great eruption having occurred anywhere. From Vesuvius small streams of lava issued in February and toward the end of July, and again in September, October and November. So also Etna showed some activity in February which lasted until May, consisting, however, mostly of showers of ashes. Other eruptive phenomena were the sand shower in St. Domingo on January 4, the elevation of the Island in Lake Ilopango in January, the eruption of Fuego in Guatemala June 29, and the eruption of Mauna Loa Nov. 5.

Earthquakes are recorded to the number of 225, of which 65 are American, showing that the deficiency of such items in previous reports was due, as was supposed, to want of full information, and not to any dearth of such phenomena upon the Western continent. Of these 65, all but one have already been noted in this Journal. The earthquakes of the year were divided among the seasons as follows:

Winter, 80—Dec. 43, Jan. 18, Feb. 19;
Spring, 32—March 15, April 9, May, 8;
Summer, 59—June 10, July 28, August 21;
Autumn, 54—Sept. 14, Oct. 9, Nov. 31.

On thirty-three days in the year shocks occurred at two or more distant places, and thirty-two places were affected at two or more times. A few earthquakes are of sufficient interest to merit more special notice.

Those of San Salvador in January and February, in Cuba, Florida and Mexico in the latter part of January, and the destructive shocks in the Philippines in July, have already been mentioned in this Journal.

On November 9, the city of Agram, after numerous less important shakings during the summer, was affected by a violent earthquake, which extended over Croatia, Montenegro, and a great part of Hungary and Bosnia, and even to Bohemia and upper Italy. This, the most severe shock, was followed by numerous others in gradually decreasing intensity, so that up to the 18th December, 61 distinct shocks had been observed in the city, with minor vibrations innumerable. The city appears to have suffered frequently in the past, as a list is given of 33 earthquakes which have occurred there since 1502. The author remarks on the continuance of the subterranean noises when the shocks had ceased and the ground was at rest. The phenomena still continued at the end of the year.

On July 4 all Switzerland was shaken by an earthquake, which had its origin in the neighborhood of the Simplon.

Smyrna and its vicinity suffered on the 22d of June, and again on the 29th of July, when the shocks extended to the neighboring islands and did much damage. In Smyrna itself one hundred houses were overthrown and thirty persons were killed. The centre of disturbance was in the mountains northeast of the city, where the village of Menemen was left uninhabitable. This earthquake has been described in the French scientific journals. This same region has again been shaken by the Scio earthquake of 1881, as mentioned above.

On September 2d an earthquake at Kalavrita, in the Peloponnesus, was felt also on the other side of the Mediterranean at Tripoli, in Africa.

Dr. Fuchs records some observations on the slight vibrations which Prof. Perrey has reported as occurring frequently in Nice. They are only perceptible at night when all is still, and he is inclined to refer them to the dashing of the waves upon the shore, although he states that the intensity of the vibration does not correspond to that of the wave action, nor yet do the intervals between the vibrations correspond to the intervals between the waves. He suggests that the *direction* in which the waves strike may have influence on the phenomena.

C. G. R.

ART. XLI.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern coast of New England, No. 2*; by A. E. VERRILL. (Brief Contributions to Zoology from the Museum of Yale College: No. XLVIII.)

THE U. S. Fish Commission has occupied, this season, the station at Wood's Holl,* Mass., on Vineyard Sound, where a laboratory for its use was established in 1875.

The shallower waters of that region had been very fully explored by the Fish Commission in 1871 and 1875. Nevertheless, much has been done this year toward completing the investigation of the surface fauna, which is exceedingly rich and varied at Wood's Holl. The larval forms of crustacea, annelida, echinodermata, mollusca, etc., have been taken in large numbers in the towing nets, as well as adult forms of many kinds, including, especially, numerous species of Syllidæ, many of which are new.

The special subject for investigation this year, was, however, the rich fauna that was last year discovered in deep water, about 75 to 120 miles off the southern coast of New England, near the edge of the Gulf Stream. A brief account of our discoveries in that region last season was published by me in this Journal (vol. xx, p. 390), with notices and descriptions of many of the mollusca and echinoderms then discovered. A more detailed account of the mollusca was published by me in the Proceedings of the National Museum (vol. iii, pp. 356–409, Dec.–Jan.). Professor S. I. Smith published an account of the crustacea in the same Proceedings (vol. iii, pp. 413–452, Jan., 1881).

In the following articles I propose to notice some of the more interesting species, whether obtained this year or last year. Some of these species were also dredged on the 16th of last November, by Lieut. Z. L. Tanner, in a trip made to the deep water off the mouth of Chesapeake Bay, after the regular dredging operations of the season had ceased.

As many of the species there obtained are referred to, a list of the stations is here added:

Station.	Locality.		Fathoms.	Bottom.
	N. Lat.	W. Long.		
896	37° 26′	74° 19′	56	sand, shells.
897	37 25	74 18	157½	sand, mud.
898	37 24	74 17	300	mud.
899	37 22	74 29	57½	sand.
900	37 19	74 41	31	sand.
901	37 10	75 08	18	sand.

Our dredgings this year, in deep water, have also been made with the "Fish Hawk," Lieut. Z. L. Tanner, commander. Mr.

* Formerly written "Wood's Hole," but the name was changed by an act of the Legislature of Massachusetts, in 1875.

A. P. Chapin, of Warsaw, N. Y., made the temperature observations and records of soundings, etc.

The party immediately associated with the writer in the zoological investigations consisted of Professor S. I. Smith and Mr. J. H. Emerton (artist), of Yale College; Dr. T. H. Bean and Mr. Richard Rathbun, of the National Museum; Mr. Sanderson Smith, of New York; Professor L. A. Lee, of Bowdoin College; Mr. B. F. Koons, Mr. E. A. Andrews, and Mr. H. L. Bruner, graduates and special zoological students of the Sheffield Scientific School of New Haven, and Mr. Peter Parker, of Washington. Most of these gentlemen have been associated with me, in the same way, in previous years.

The off-shore regions explored this year are included between N. lat. 39° 40′ and 40° 22′; and between W. long. 69° 15′ and 71° 32′. They occupy a region about 42 miles wide, north and south; and about 95 miles long, east and west, or about 105 miles along the 100-fathom line.

Series of dredgings have also been made this season, off Cape Cod; in Vineyard Sound; in Buzzard's Bay; and off Martha's Vineyard, between the deep-water and shallow-water localities of former years. Other dredgings will be made later, this season.

It is probable that the remarkable richness of the fauna in this region, both in the number of species and in the surprising abundance of the individuals of many of them, is due very largely to the unusual uniformity of the temperature enjoyed, at all seasons of the year, at all those depths that are below the immediate effects of the atmospheric changes. The region under discussion is subject to the combined effects of the Gulf Stream on one side and the cold northern current on the other, together with the gradual decrease in temperature in proportion to the depth. It is, therefore, probable that at any given depth, below 50 fathoms, the temperature is nearly the same at all seasons of the year. Moreover, there is, in this region, an active circulation of the water, at all times, due to the combined currents and tides. The successive zones of depth represent successively cooler climates more perfectly here than near the coast. The vast quantities of free-swimming animals, continually brought northward by the Gulf Stream, and filling the water, both at the surface and bottom, furnish an inexhaustible supply of food for many of the animals inhabiting the bottom, and probably, directly or indirectly, to nearly all of them. A very large species of *Salpa*, often five or six inches long, occurs both at the surface and close to the bottom, in vast quantities. Sometimes several bushels come up in a single haul of the trawl. I have taken this same *Salpa*, in very numerous instances, from the stomachs of starfishes of many kinds, from Actiniæ of

Table of Outer Stations, occupied in 1881, *with Temperatures of bottom and surface.*

The distances are measured from Gay Head Light, in geographical miles. The bearings are magnetic.

Stat.	Locality.	Fath.	Bottom.	Date.	Temperature.		Hour.
					Bott'm.	Surf'ce	
	Off Martha's Vineyard.						
917	S. ½ W. 59½ m.	43	gn. mud	July 16	42° F.	63° F.	4.10 A. M.
918	" 61 "	45	"	"	45	63	5.33 "
919	" 65 "	51½	"	"	42·5	66	7.00 "
920	" 68½ "	61	"	"	49	66	8.20 "
921	" 73 "	65	"	"	52	70	9.40 "
922	" 77 "	69	gn. m. sd.	"	52	72	10 57 "
923	" 78½ "	96	sand	"	52	72	12.27 P. M.
924	" 83½ "	160	"	"	44·5	71	1.52 "
925	" 86 "	224	sd. m.	"	42	71	3.35 "
926	" 85 "	195	"	"	44	71	5.24 "
935	S. by E. ½ E. 106½ m.	770		Aug. 4	39·5	70	8.14 A. M.
936	" " 104½ "	705	mud	"	39·5	71	10.43 "
937	" " 102 "	506	gn. s. m.	"	40·5	72	12.45 P. M.
938	" " 100 "	310	"	"	42	72·5	2.44 "
939	" " 98 "	258	"	"	47	73	4.25 "
940	" " 97 "	130	sand	"	52	72	5.30 "
941	" " 89½ "	76	sd. mud	"	52	71	7.45 "
942	S. by W. ¾ W. 81½ "	134	"	" 9	50	69	6.15 A. M.
943	S.S.W. 83 "	153	sd. m. sh.	"	49	70	7.10 "
944	" 82 "	124	"	"	51	70	8.27 "
945	S. by W. ¾ W. 84½ "	202	gn. m. sd.	"	44	71	12.05 P. M.
946	" " 87½ "	241	"	"	47	71	2.00 "
947	" " 89 "	312	sd. m.	"	44	70	4.00 "
949	S. 79½ "	100	y. mud	" 23	52	66	4.20 A. M.
950	" 75 "	69	s. sh. mud	"	52	65	5.50 "
951	" 85 "	219	mud	"	41	67·5	9.40 "
952	S. ¼ E. 87½ "	388	y. m. sd.	"	40	68	11.28 "
953	S. ½ E. 91½ "	715	mud	"	39·5	68	2.30 P. M.
954	" 91 "	642	sd. mud	"	39·5	68	4.50 "
994	S.S.W. ¼ W. 104½ "	368	mud	Sept. 8	40·5	68	4.50 A. M.
995	" " 104½ "	358	y. m. sd.	"	40·5	68	6.32 "
996	" " 104 "	346	"	"	40	67·5	7.35 "
997	" " 103½ "	335	y. m.	"	40	67·5	9.03 "
998	" " 102½ "	302	gr. m.	"	40	68	10.34 "
999	" " 100 "	266	"	"		68	11.48 "
1025	S.S.W. ¼ W. 95 "	216	"	"	45	69	1.05 P. M.
1026	" " 93½ "	182	"	"	47·5	69	2.55 "
1027	S.S.E. ¾ E. 105½ "	93	fine sand.	" 14	48½	65	7.23 A. M.
1028	" " 108½ "	410	y. mud.	"	41	66	9.01 "
1029	" " 109½ "	458	"	"	40	68	12.13 P. M.
1030	" ⅞ 108½ "	337	"	"	41	66	1.52 "
1031	" ⅝ 107½ "	255	"	"	46	65	2.54 "
1032	" ½ 107 "	208	"	"	46	65	4.00 "
1033	" " 106 "	183	sd. gravel.	"		63	4.55 "
1034	" " 105½ "	146	sd. y. mud.	"	46½	62	5.55 "
1035	" " 103½ "	120	sand.	"	47	62	6.56 "
1036	" " 102 "	94	sand.	"	51	61½	7.54 "

several species, etc. Pteropods also frequently occur in the stomachs of the starfishes, while Foraminifera furnish a large part of the food of many of the mud-dwelling species.

The fishes, which are very abundant and of many species, find a wonderfully abundant supply of most excellent food in the very numerous species of crabs, shrimp and other Crustacea, which occur in such vast quantities, that not unfrequently many thousands of specimens of several species are taken in a single haul of the trawl. Cephalopods are also abundant and are eagerly devoured by the larger fishes, while others prey largely upon the numerous gastropods and bivalves.

Fishes.

The fishes obtained by us are of great interest. The large number of species taken will be indicated by the accompanying list, which has been kindly made out for me by Dr. T. H. Bean, who has had charge of the fishes this season. A considerable number of species, not included in this list, are either undescribed or not fully identified. These will soon be published in a more detailed list.

The new species of fishes taken in 1880, in this region, were described by Mr. G. Brown Goode, and a list of the 51 species, obtained by us, was also published by him (Proc. Nat. Mus., iii, pp. 337–467, Nov., 1880, and Feb., 1881).

The most important of the fishes, is the *Lopholatilus chamæleonticeps* Goode and Bean, or "Tile-fish." This is a large and handsome edible fish, first discovered on these grounds in 1879, and not yet found elsewhere. It seems to be very abundant over the whole region explored by us, in 70 to 134 fathoms. On one occasion a "long-line" or "trawl-line" was put down at station 949, in 100 fathoms, and 73 of these fishes were taken, weighing 541 pounds. These varied in weight from 2½ to 31 pounds. It is brownish gray, more or less covered with large bright yellow spots. The *Peristedium miniatum* Goode, is a very curious and handsomely colored fish, often bright red throughout. The several species of "hake" (*Phycis*) are common, as well as the "whiting" (*Merlucius bilinearis*). Large specimens of the "goose-fish" or "angler" are often taken in the trawl, in as much as 250 fathoms.

List of Fishes. By Dr. T. H. Bean.

1. *Halieutæa senticosa* Goode.
Taken at 9 stations; 160 to 335 fathoms; abundant at stations 925 and 951.

2. *Lophius piscatorius* Linn. (Goose-fish).
Stations 919, 944 and 997; 51½ to 335 fathoms; one at each station.

3. *Centriscus scolopax* Linn. (Trumpet-fish.)
One trawled at station 940, in 130 fathoms.

4. *Hippoglossoides platessoides* (Fabr.) Gill. (Flounder.)
Taken sparingly at stations 917 and 918; 43 to 45 fathoms.

5. *Paralichthys oblongus* (Mitch.) Jordan. (4-spotted Flounder.)
Abundant at station 923, in 96 fathoms; a few taken at 917, 919 and 940, in 43 to 130 fathoms.

6. *Monolene sessilicauda* Goode.
A single one caught at 923, in 96 fathoms, sand.

7. *Citharichthys arctifrons* Goode.
Abundant at numerous stations, in 51½ to 130 fathoms.

8. *Glyptocephalus cynoglossus* (Linn.) Gill. (Pale-flounder.)
Occurred at 13 stations, in 160 to 506 fathoms; abundant at 994.

9. *Macrurus Bairdii* Goode and Bean. (Baird's Grenadier.)
Obtained at 15 stations, in 160 to 506 fathoms; usually abundant.

10. *Macrurus carminatus* Goode. Grenadier.
Taken at 7 stations, in 182 to 396 fathoms; abundant only at 951 and 952.

11. *Phycis chuss* (Walb.) Gill. (Hake.)
Trawled at 5 stations in 43 to 130 fathoms; abundant at 918, 919 and 923.

12. *Phycis tenuis* (Mitch.) DeKay. (Hake.)
Secured at 12 stations, in 43 to 506 fathoms; abundant only at 942.

13. *Phycis Chesteri* Goode and Bean. (Chester's Hake.)
Caught at 15 stations, in 160 to 506 fathoms; generally abundant.

14. *Physiculus Dalwigkii* Kaup.?
A single young individual was taken at station 952, in 396 fathoms.

15. *Physiculus*, sp.
Three young examples were obtained at station 941, in 76 fathoms.

16. *Enchelyopus cimbrius* (Linn.) Jordan. (Rockling.)
Taken in small numbers at 918, 946, 951 and 998; 45 to 302 fathoms.

17. *Merlucius bilinearis* (Mitch.) Gill. (Whiting.)
Found at 13 stations, in 100 to 312 fathoms; usually scarce at these depths.

18. *Ophidium*, sp. undetermined.
14 individuals were trawled at station 941, in 76 fathoms.

19. *Lycodes Vahlii* Reinhardt.
A single individual at each of two stations, 952 and 998, 302 to 396 fathoms.

20. *Lycodes Verrillii* Goode and Bean.
Taken at 11 stations, in 216 to 368 fathoms; never abundant.

21. *Zoarces anguillaris* (Peck) Storer. (Eel-pout.)
One obtained at station 918, in 45 fathoms.

22. *? Liparis vulgaris* Fleming.
Found at station 918, in 45 fathoms, in the gill-cavity of *Pecten tenuicostatus*.

23. *Careproctus Reinhardtii* Kröyer.
Taken in small numbers at 5 stations, in 202 to 310 fathoms.

24. *Peristedium miniatum* Goode.
Rare at stations 922, 940 and 950; 69 to 130 fathoms.

25. *Amitra liparina* Goode.
Found at 5 stations, in 310 to 506 fathoms; not common.

26. *Cottunculus microps* Collett.
Obtained at 7 stations, in 224 to 396 fathoms; not common.

27. *Cottunculus torrus* Goode, MSS.
A single specimen was taken at station 994, in 368 fathoms.

28. *Cottus octodecimspinosus* Mitchill. (Sculpin.)
One individual was trawled at 917, in 43 fathoms.

29. *Sebastes marinus* (Linn.) Lütken. (Rose Fish.)
The only one seen was obtained in 241 fathoms, at station 946.

30. *Setarches parmatus* Goode.
Found at stations 939, 946, 950, in 69 to 258 fathoms; abundant at 940 only.

31. *Lopholatilus chamæleonticeps* Goode and Bean. (Tile Fish.)
8 individuals were caught on a trawl-line, near station 942, in 134 fathoms; and 73 at station 949, in 100 fathoms.

32. *Hoplostethus mediterraneus* Cuv. and Val.
A young example at station 998; one at 1025 and two at 1026; 182 to 302 fathoms.

33. *Scopelus*, species undetermined.
Abundant at several stations, in 182 to 724 fathoms.

34. *Scopelus*, species undetermined.
Found sparingly at several stations, in 182 to 506 fathoms.

35. *Stomias ferox* Reinhardt.
Single individuals were caught at 936, 953 and 995; 358 to 724 fathoms.

36. *Conger vulgaris* Cuv. (Conger Eel.)
One specimen was obtained at 919, and one at 941; 51½ to 76 fathoms.

37. *Nemichthys scolopaceus* Richardson. (Snipe Eel.)
7 individuals were taken at 5 stations, in 216 to 506 fathoms.

38. *Synaphobranchus pinnatus* (Gronow) Günther. (Long-nosed Eel.)
Found at 10 stations, in 219 to 506 fathoms; common.

39. *Simenchelys parasiticus* Gill. (Pug-nosed Eel.)
A few specimens were obtained at station 937, in 506 fathoms.

40. *Raia eglanteria* Lac. (Skate.)
Taken sparingly at 924 and 940, in 130 to 160 fathoms.

41. *Raia lævis* Mitchill. (Barn-door Skate.)
Found at several stations, in 43 to 202 fathoms: abundant at 942 and 949.

42. *Raia radiata* Donovan. (Skate.)
Found in small numbers at stations 924, 946 and 951; 160 to 241 fathoms.

43. *Centroscyllium Fabricii* (Reinh.) Müll. and Henle. (Black Dog-fish.)
Taken at stations 952 and 994, in 368 to 396 fathoms; rare.

44. *Petromyzon marinus* Linn. (Lamprey.)
A single specimen was taken in 241 fathoms, at station 946.

45. *Myxine glutinosa* Linné. (Hag Fish.)
Trawled at 4 stations, in 160 to 258 fathoms; usually rare, but abundant at 951.

Mollusca.

Most of the mollusca recorded in my papers of last year were again obtained this season, and often in larger numbers. A complete list will be published in a future paper. At the present time I shall refer only to some of the more important ones, and to some of those that are additions to the fauna.

Of the Cephalopods, the following species were taken:

Gonatus Fabricii Steenstrup.*

Station 953; 715 fathoms; one large and perfect male specimen. Station 1031; 255 fathoms; one young specimen.

The former is the form recently figured by Steenstrup, under the above name, and considered by him the adult of *Gonatus amœnus*.

* A direct comparison of this individual with the mutilated specimen described, by me, last year, as *Chelotenthis rapax*, shows that they are probably identical. The latter was separated, as a genus, from *Gonatus*, as understood by Steenstrup (=*Lestoteuthis* Verrill) mainly because the ventral arms appeared to have had two interior rows of *hooks*, like those on the other arms, while in *Gonatus* they are

Ommastrephes illecebrosus Verrill.

Stations 918, 919, 923–925, 939, 940, 949, 1025, 1033; 45–258 fathoms.

Taonius pavo (Les.) Steenstrup.

Station 952; 388 fathoms. Two specimens. This rare species has not been recorded from our coast, since it was described by Lesueur, in 1821.

Rossia sublevis Verrill.

Stations 924, 925, 939, 945–947, 951, 952, 997, 1025, 1026, 1028, 1029, 1032, 1033; 106–388 fathoms. Some of the specimens, recently obtained, agree more nearly with *R. glaucopis* Lov., as figured by G. O. Sars, than any seen before. It may prove to be identical.

Heteroteuthis tenera Verrill.

Stations 918, 919, 920, 921, 922, 940, 944, 949, 950, 1026, 1027; 45–182 fathoms. Eggs of this species were taken at stations 922, 940, 949, and in several localities in 1880. They are nearly round, ivory-white or pearly, attached to shells, etc., by one side, in groups, or scattered. On the upper side there is a small conical eminence.

Sepiola leucoptera Verrill.

Stations 947, 952, 998, 999, 1026 (3 juv.); 182–388 fathoms.

Octopus Bairdii Verrill.

Stations 925, 939, 945–947, 951, 952, 994, 997, 998, 1025, 1026, 1028, 1033, 1035; 103–388 fathoms.

composed of suckers, like the outer rows; but the horny parts had been destroyed, in my specimen, and the hook-shaped form of the fleshy part of the suckers was probably due to post-mortem changes. By careful treatment with reagents I have been able to restore some of the distal ones more completely, so as to show a distinctly sucker-like form.

It would, however, be difficult, without farther evidence, to believe that *Gonatus amœnus*, as figured by G. O. Sars, is the young of this species, for he neither mentions nor figures the remarkable series of lateral connective suckers and tubercles on the tentacular clubs, though he gives detailed figures of the club and its other hooks and suckers. That so careful an observer as Sars should have overlooked such a structure seems almost incredible. The two small specimens that I have hitherto seen from America, agreed well with Sars' figures, but both were considerably injured from having been in fish-stomachs. A small specimen (mantle 30^{mm} long) recently taken by us, at station 1031, is, however, well preserved, and while agreeing with *G. amœnus* in all other respects, it has the peculiar lateral connective suckers and tubercles of the club, seen in *G. Fabricii*, adult. These organs are, however, very minute in this specimen, but sufficiently evident to convince me that Steenstrup is correct in considering *G. amœnus* the young of *G. Fabricii*.

Since Steenstrup has shown that the type of my genus *Lestoteuthis* is the same genus as *Gonatus* (adult), and therefore that *L. robustus* (Dall), doubtfully referred to it by me, is a distinct genus, I propose to make the latter the type of a new genus: *Moroteuthis*. Its most prominent distinctive character will be the remarkable solid cartilaginous cone, superadded to the end of the pen, and corresponding in form and position with the solid cone of *Belemnites*.

Alloposus mollis Verrill.

Stations 937, 938, 952, 953, 994; 310–715 fathoms. Two very large females were taken: one at station 937, in 506 fathoms; the other at 994, in 368 fathoms. The former weighed over 20 pounds. Length from end of body to tip of 1st pair of arms, 31 inches; of 2d pair, 32; of 3d pair, 28; of 4th pair, 28; length of mantle beneath, 7; beak to end of 4th pair of arms, 22; breadth of body, 8·5; breadth of head, 11; diameter of eye, 2·5; of largest suckers, ·38.

The only additional Pteropod taken this year is *Triptera columnella* (Rang), from station 947. Among the Gastropods there are a considerable number of species not obtained last year. Perhaps the most remarkable discovery, in this group, is a fine typical species of *Dolium* (*D. Bairdii*) taken alive, in 202 fathoms. This genus is almost exclusively tropical in its distribution. On our coast, *D. galea* extends northward to North Carolina. This southern form, with a large *Marginella*, taken both this year (station 949) and last, an *Avicula*, and various other genera, more commonly found in southern waters, are curiously associated, in this region, with genera and species which have hitherto been regarded as exclusively northern or even arctic, many of them having been first discovered in the waters of Greenland, Spitzbergen, northern Norway, Jan Mayen Land, etc.

Among the northern species which had not been found previously south of Cape Cod, the following were dredged: *Trophon clathratus*, 972, 976; *Acirsa costulata* (=*borealis*), 965; *Amauropsis Islandica* (=*helicoides*); *Margarita cinerea*, 981; *Machæroplax bella*, 1032; *Cylichna Gouldii*, 973; *Odostomia* (*Menestho*) *striatula*, 980.

Dolium Bairdii Verrill and Smith, sp. nov.

A moderately large species, having nearly the form of *D. perdix* and *D. zonatum*. Male. Shell broad ovate, with seven broadly rounded whorls; spire elevated, apex acute; nuclear whorls about three, smooth; suture impressed, but not deep, nor channelled, the last whorl is somewhat flattened (perhaps abnormally) below the suture, for some distance, corresponding to an inward flexure of the outer lip. Aperture elongated, irregularly ovate; outer lip regularly rounded, except for a short distance posteriorly, where it is slightly incurved, its edge is excurved, acute externally, distinctly but not prominently crenulated within, except posteriorly, where a posterior canal is slightly indicated; columella straight; canal short and broad. The sculpture is peculiar: it consists of numerous (about 40 on the last whorl) rather prominent, squarish, clearly defined revolving ribs, less than 1^{mm} broad, separated by interspaces of about

the same breadth, in which there is usually one small narrow rib, alternating with the larger ones; sometimes there are two or more small ones. The whole surface, both of ribs and interspaces, is covered with fine and regular transverse, raised lines. The surface is covered with a very thin pale olive-yellow epidermis, easily deciduous when dry. Color white, except that the larger ribs are alternately light brown and white, and the apex, consisting of about three smooth nuclear whorls, is dark brown. Length 68^{mm}; breadth 56^{mm}; length of aperture 53^{mm}.

The animal is well preserved. Proboscis blackish, exserted about 20^{mm}, thick (8^{mm}) and clavate at the end, which is surrounded by a sort of collar, with a finely wrinkled or crenulated, white edge. Head large, with a prominent rounded lobe in front. Tentacles large, elongated (10^{mm}), stout, tapering, obtuse. Eyes small, black, on distinct, but slightly raised tubercles at the outer base of the tentacles. Head, tentacles and siphon-tube dull brown. Penis very large (50^{mm} long, 12^{mm} broad), twisted and thickened at base, flattened distally, terminating in a slightly prominent obtuse lobe at the tip; a well-marked groove runs along the posterior edge to the tip.

Off Martha's Vineyard, station 945; 202 fathoms. Station 1036; 94 fathoms; one young specimen and large fragments.

Pleurotoma (*Bela*) *limacina* Dall. (*Daphnella ?*)

Bulletin Mus. Comp. Zool., ix, p. 55, 1881.

Four living specimens of this elegant shell were taken at station 994; 368 fathoms. Gulf of Mexico, 447–805 fathoms (Dall). This is not a true *Bela*, for it has no operculum; eyes minute.

Capulus hungaricus (Linné).

Two living specimens were obtained, which appear to belong to this species. They are more delicate and have somewhat finer and more regular radiating ribs than the ordinary European form. It has not been recorded before from our coast.

Stations 922, 1029; 69 and 458 fathoms.

Fiona nobilis Alder and Han.

British Nud. Moll., Æolidæ, Fam. 3, pl. 38A.

A large and handsome *Fiona*, apparently this species, was found in two instances, in large numbers, on pieces of floating timber, among Anatifers, at stations 935 and 995. They were kept in confinement several days and laid numerous clusters of eggs. These are in the form of a broad ribbon, spirally coiled in about one and a half turns, so to form a bell-shaped or cup-shaped form, and attached by a slender pedicel, so as to hang from the under sides of objects. Alder and Hancock recorded its occurrence, in a single instance, at Falmouth, England.

Issa ramosa Verrill and Emerton, sp. nov.

Body elevated, convex above, elongated, oblong, sides nearly parallel along the middle; foot well-developed, as broad as the body. Dorsal tentacles thick, clavate, obtuse, with numerous lamellæ; sheath scarcely raised. Back and sides with numerous small, simple papillæ. Along the lateral margins of the back there is a carina, with a row of large, much branched papillæ, alternating with much smaller ones; of the large ones there are about six on each side, the most anterior are below the dorsal tentacles; two on each side are posterior to the gills, the last ones largest; a row of similar but smaller processes extends below the tentacles and around the front margin.

Gills five, arborescently branched. Color, pale yellow. The dorsal tentacles darker.

The radula is quite different from that of *I. lacera* and *Triopa claviger*. The median area is wide, with two rows of thin, transversely oblong plates; there are three rows of large, nearly equal teeth on each side, with the tips strongly incurved, obtuse; the innermost tooth has a small lobe on the middle of the inner edge: these are followed by about seventeen or eighteen smaller, oblong plates, with slightly emarginate anterior ends; these gradually decrease in size toward the margins of the radula.

Stations 940, 949; 130 and 100 fathoms.

In form, this resembles *I. lacera*, but is easily distinguished by the branched appendages along the sides.

Of the Lamellibranchiata, some very interesting new forms occurred. The most important of these are species of *Pholadomya*, *Mytilimeria* and *Diplodonta*,—three genera not before found on this coast. The *Pholadomya* is more related to certain fossil forms than to any of the few described living species. The genus *Mytilimeria* has hitherto had very few living representatives, and none of them resemble our very singular species.

Among the northern forms, not previously found south of Cape Cod, are the following: *Mya truncata; Spisula ovalis* (975, 976, 981); *Leda tenuisulcata* (973); *Nucula tenuis.*

Pholadomya arata Verrill and Smith, sp. nov.

Shell triangular, short, wedge-shaped, posterior end angular, somewhat produced, obtuse; anterior end very short and abruptly truncated, clearly defined by a carina extending from the beak to the outer margin; anterior to the carina there is a broad concave furrow, which bounds the slightly convex central area of the front end; the greater part of the sides of the shell is covered with deep, rather wide, concave furrows, separated by elevated, sharp-edged ribs; the furrows vary in width and decrease

posteriorly; a small portion, near the tip of the posterior end is covered only by slight ribs. The surface between the ribs is finely granulated. When the thin superficial layer is removed the surface is pearly. The umbos are prominent, strongly incurved, nearly or quite in contact. The hinge in the right valve consists of a small, slightly prominent lamella, running back as a low ridge, and separated from the margin of the shell anteriorly, and from the cartilage-lamina posteriorly, by a narrow groove; the cartilage-pit is long, running forward under the beak as a a narrow furrow; it is bounded internally by a prominent lamella. Length, 36^{mm}; height, 29 ^{mm}; breadth, 26^{mm}.

Stations 940, 949, 950; 69 to 130 fathoms.

Three specimens, all dead, but one is very fresh.

Mytilimeria flexuosa Verrill and Smith, sp. nov.

Shell obliquely cordate, short, higher than long, very swollen, the anterior end rather shorter than the posterior; umbos very prominent, beaks much incurved, pointed and turned forward, with a small, deep concavity just under and in front of them. The outline and surface of the shell is very flexuous, owing to the broad deep grooves and elevated ribs which divide the surface into several areas. The most prominent rib is very high and rounded, and runs from the beak to the extreme ventral margin, inclining somewhat forward; in front of this the anterior area is flattened with a wide shallow concave groove or undulation in the middle, and others less marked; the front edge is broadly rounded, slightly undulated below. The middle area is very elevated, and forms more than a third of the shell; it is flattened or slightly concave in the middle, and undulated by several faint broad ribs; it recedes posteriorly, and a broad concave furrow separates it from the small posterior area, which is without ribs, and has a prominent rounded edge. The surface is finely granulated, lines of growth evident. The interior is pearly, angulated by a deep groove, corresponding to the largest external rib. The dorsal hinge-line is nearly straight posteriorly, and strongly incurved anteriorly, in the right valve it projects inward, but not in the left; in the right valve there is a small rounded tubercle, a little back of the beak; from below this a short rib-like process runs back below the deep, partially internal cartilage-pit, which extends forward and upward under the beak as a narrow furrow. Anterior muscular scar deep; posterior one larger ovate, less distinct; sinus small. Length, 25^{mm}; height, 26^{mm}; breadth from side to side, 22^{mm}.

Station 947; 312 fathoms. One pair of fresh valves, dead.

This and the preceding were both taken by means of the "rake-dredge."

Diplodonta turgida Verrill and Smith, sp. nov.

Shell large for the genus, round-ovate, a little longer than high, very swollen; the two ends nearly equally rounded, the anterior a little narrower; ventral edge broadly and regularly rounded; beaks nearly central, somewhat forward of the middle, strongly curved inward and forward, acute. Surface without sculpture, smooth except for the evident lines of growth. In the right valve there are, opposite the beak, two nearly equal, stout, sharp teeth, separated by a space of about the same width; back of these, and partly joined at base to the posterior one, there is a much larger, broad, stout, obtuse tooth, with a groove on its dorsal side; external cartilage-groove and its lamella are long and narrow, curved. Length, 29^{mm}; height (umbos to ventral edge), 25^{mm}; breadth, 23^{mm}.

Station 950; 69 fathoms. One right valve.

ART. XLII.—*Note on the Tail of Comet b*, 1881; by LEWIS BOSS. With Plates V and VI.

THE changes which took place in the aspect of the tail of the great comet of 1881, during the last days of June, seemed to me of peculiar and unusual interest. Appearances so novel and unexpected moved me to prepare some rude sketches of the tail, with brief notes as to its position in the sky. From several causes my opportunities for making such studies proved to be very few, and lack of experience contributed to diminish the completeness and accuracy of the results actually obtained. It is to be regretted that the number of those who give serious and systematic attention to this branch of observation is quite small in view of the small number of opportunities; while, on the other hand, the observations which can be made are uncertain in character, and the results vary much with individual judgment. It is therefore important that drawings and descriptions should be gathered from as many sources as possible.

The engravings (Plate V), accompanying this paper were reduced from drawings compiled from the original sketches and notes.

These were made in the open air at the times of observation indicated. In all cases the chief object of interest was what may be conveniently termed the right-line tail, which was far more conspicuous than the other branch on June 26, scarcely perceptible on June 28, and entirely wanting on July 1. It is to be regretted that on these dates charts were not used in the preparation of the original sketches, except for reference. The final drawings were laid down on copies of Schwinck's polar

chart (1850) from the original sketches and notes. On July 22 the outlines of the tail were drawn with care on the *Durchmusterung* polar chart (Argelander, 1855), and from thence accurately transferred to the finished sketch. The distortion of figure, owing to the projection used, is not important in any case, and for the purposes of this communication it is inappreciable. The engraver has been very successful in preserving the accuracy of the original drawings, and in imparting to them the desired effects. The following is the substance of the notes recorded:

June 26, 10^h.—Air wonderfully transparent. The tail of the great comet consists of two branches. The principal branch appears to be perfectly straight, and passes about two degrees to the apparent east of Polaris and eight or ten degrees beyond it. For the last ten or fifteen degrees this branch is exceedingly faint. The other is curved quite strongly to the apparent west, and after its separation from the principal ray requires most careful scrutiny for its detection. It seems to extend to a point six or seven degrees, astronomically southeast from Polaris.

June 26, $13^h\ 30^m$. Sketch.—The tail presents to the naked eye much the same appearance as it did earlier in the evening, except that neither branch can be traced so far as then seen. The straight branch appears to pass quite centrally over 2 Ursæ Minoris, and to extend about two degrees beyond B. A. C. 7851. Its breadth seems to be nearly uniform and a little more than one degree. With the aid of a straight edge no curvature could be safely assigned. There is a rather sudden falling off in brightness at a point four or five degrees from 2 Ursæ Minoris toward the nucleus. The edges of this ray are ill-defined and the central parts brightest. The ray which curves toward greater right ascension is not satisfactorily seen. Its effect is to broaden and intensify the principal ray for a distance from the nucleus equal to about four-tenths the whole distance to Polaris. At this point the total breadth of the tail is estimated to be about four degrees. Here a separation is faintly indicated, but the continuation of the curved ray is observed with extreme difficulty. The direction and extent of this branch is indicated on the sketch.

June 28, 13^h. Sketch.—Foggy haze low down in the north. Sky otherwise satisfactory. The nearly straight ray described on June 26 has dwindled to a faint and narrow streak, which might have been overlooked, had not a bright one been expected in its place. It extends to a point near 2 Ursæ Minoris as indicated in the sketch. Its breadth is not over one-third of a degree. The curved branch is brightest in its central parts, and is very conspicuous for the first ten or fifteen degrees of its length. It seems to terminate about three degrees short of B. A. C. 4349; though at times a much greater extent is suspected. Fifth magnitude star (B. A. C. 2326) is 15′ inside the following edge of the tail. The axis of this branch passes to the apparent east of

B. A. C. 4349, and at a distance from it equal to about one-fifth the distance between that star and Polaris. The last direction of the axis is toward β Ursæ Minoris. The distance of Polaris from the preceding edge of the tail is nearly equal to the distance between Polaris and 2 Ursæ Minoris. The breadth at three-fourths the distance from the nucleus is about three degrees.

July 1, $12^h\ 15^m$. Sketch.—State of sky not remarkably fine. The tail is much shorter than heretofore, and its appearance entirely changed. There is no trace of the straight ray seen on June 26 and 28. The preceding edge of the tail appears nearly straight. It is brighter and extends to a greater distance from the nucleus than the following edge. The latter is strongly curved near the end. The breadth is about three degrees at the widest part.

July 13, $10^h\ 15^m$.—Tail single, faint, and diffuse. Estimated length seven degrees. Breadth near the end, about 40′. The direction of the axis prolonged passes to the east of ε Ursæ Minoris, at a distance about one fifth that between ε and δ Ursæ Minoris.

July 22, 14^h. Sketch.—Four-inch Clark Comet seeker. Power twelve. Field 2° 30′. Sky fine. Two branches seen. The first is nearly straight and brighter than the other. Estimated width 10′. This branch is certainly recognized as far as A. R. $14^h\ 20^m$. Sometimes I imagine that it extends as far as A. R. $15^h\ 40^m$. [As indicated by the dotted line in diagram.] The light seems to be composed of a great number of parallel bright streaks. This appearance of striation is very decided in the region within two degrees of the nucleus. The southern branch is curved and much shorter and fainter than the straight ray. The location of the last degree of length represented in the sketch is very difficult. The breadth here is estimated to be 30′ or 40′. The bounding lines are carefully laid in on the *Durchmusterung* chart, and their position relatively to stars frequently compared with the sky during the progress of the sketch. Sky suddenly clouded at $14^h\ 30^m$.

During the remainder of July the appearance of the tail did not essentially change. I was absent from the observatory for a short time in the early part of August, and did not again obtain a telescopic view of the tail until August 17. It was then apparently single. The estimated length was 3°. There are slight inconsistencies in the notes of June 28, which have been adjusted according to the supposed weights of the various estimations.

For the points most carefully determined, and with such approximation as appears to be warranted by the precision of the observations, we have for positions of points in the tails on the respective dates:

TABLE I.

	Nucleus.		Axis, right-line tail.		Curved tail.		Point in curved tail observed.
	α	δ	α	δ	α	δ	
June 26, $13^h\ 30^m$	87°·2	57°·9	316°	83°·0	99°	80°·5	Axis.
	----	----	13·2	85·6	----	----	
June 28, $13^h\ 00$	90·1	63·9	20·	85·9	155	86·0	Axis.
	----	----	----	----	100	83·0	Axis.
July 1, $12^h\ 15^m$	95·8	70·7	----	----	111·2	87·0	Prec. edge.
	----	----	----	----	115·3	80·0	Foll. edge.
July 22, $14^h\ 00$	177·6	81·9	215·4	82·8	205·0	82·2	Axis.

It would have been better, no doubt, to have made no special effort to determine the position of the extreme visible limit of the tail, but to have given greater attention to the position of the axis and the breadth of the visible portions at points where the tail could be easily seen. But even with the present imperfect data, we shall be able to derive some idea of the real position of the tails in space, and of their correspondence in type with others which have been observed.

Convenient formulæ have been devised by Bessel (Astr. Nachr., vol. xiii, p. 193), by the use of which we may determine the angular deviation of a point in the tail from the radius vector prolonged. It will be necessary to assume that the axis of the tail lies in the plane of the orbit of the nucleus. This assumption is well supported both by theory and experience, and is, no doubt, substantially correct. Such small deviations as might result when emissions of matter from the head are unsymmetrical with reference to the orbit plane, or when the initial velocity of particles thrown off from the nucleus is greater toward one pole of the orbit than toward the other, may probably be neglected as comparatively insignificant. Let:

r=Radius vector of the nucleus at the time of observation.
ρ=Geocentric distance of nucleus.
Δ=Length of tail, or distance of point observed from the nucleus.
s=Angular length of tail.
p°=Position angle at the nucleus of r prolonged.
p=Corresponding angle for the observed point in the tail.
S=The cometocentric distance of the earth from the north pole of the comet's orbit.
T=Cometocentric angle between the earth and the observed point in the tail.
φ'=The cometocentric angle between the observed point and the radius vector prolonged,—positive, when this point is on that side of the radius vector from which the comet has been moving.

From the elements of Dr. Oppenheim (Astr. N., 2384), we find for the coördinates of the north pole of the orbit of comet *b*, referred to the equator,

$$A=192^\circ\ 09'. \qquad D=+23^\circ\ 46'.$$

We then derive the following table of results:

TABLE II.

	June 26.			June 28.			July 1.		July 22.	
	Axis of right-line tail at end.	Axis of right-line tail at 2 Ure. Mn.	Axis of curved tail at end.	Axis of right-line tail at end.	Axis of curved tail at end.	Axis of curved tail near B. A. C. 2326.	Preceding edge at end.	Following edge at end.	Axis of right-line tail at end.	Axis of curved tail at end.
r	·763	----	----	·775	----	----	·795	----	1·018	----
ρ	·340	----	----	·374	----	----	·428	----	·853	----
Δ	·210	·187	·179	·161	·189	·153	·130	·110	0·82	·057
s	37°·0	31°·1	22°·9	25°·0	24°·7	19°·2	16°·4	10°·4	5°·0	3°·9
p°	345·6	----	----	348·6	----	----	353·1	----	57·7	----
p	351·2	351·8	5·0	350 8	8·7	3·7	2·8	18·6	61·5	71·8
S	102·9	----	----	106·1	----	----	110·3	----	121·6	----
T	40·2	39·1	24·9	54·0	30·0	34·4	51·8	32·9	109·8	94·1
φ'	12·9	14·0	29 8	5·6	32·1	27·0	21·1	41·5	6·2	24·9
							31·3			

An inspection of the foregoing table shows that the characteristics of the two branches of the tail, as defined by the values of φ', present a similarity quite as striking as could have been predicted in view of the considerable probable errors to which such determinations are liable. On the first three dates the cometocentric elevation of the earth above the plane of the comet's orbit was, respectively, 13°, 16°, and 20° only; so that small errors in the observed position angle are considerably multiplied when converted into the corresponding values of φ'. It must also be remembered that many of the points observed are several degrees farther from the nucleus than the superior limit of visibility assigned by most observers for the extent of the tail on the respective dates.

So far as I am aware most of the observers who have already reported on the appearance of the tail failed to notice the division into branches at all. On the other hand, it cannot be supposed that this interesting aspect entirely escaped detection under proper conditions of sky and terrestrial surroundings.

If we examine similar computations which have been made on the tails of other great comets we see that the two branches resemble the two types most frequently observed. The right-line tail corresponds to the principal appendages of the great comets of 1811, 1835 (Halley's), 1843, 1861, 1862, and others. The general direction also conforms to that of the secondary tail of the great comets of 1858, 1874 and others; but in the present case the light of this tail is relatively far more conspicuous. The branch of greater curvature finds its representative in the great majority of comets which have been observed.

The tail of the comet of 1807 presents most striking resemblance to this under discussion. On October 22, 1807, the comet of that year had, generally speaking, the same position in space as the present comet had on July 22. On that occasion (Astr. Nachr., vol. xiii, p. 228), Bessel found two tails. The first he considered to be nearly straight and in length about 4·5°. The other was strongly curved, broader than the first, and in length about 3°. Dr. Bredichin (Mosc. Ann., vol. v, pt. 2, p. 56), has computed the value of φ' for the end of each tail. This enables us to compare the two descriptions in a very satisfactory manner. We have—

	Comet of 1807.			Comet of 1881.		
	Δ	ρ'	s	Δ	ρ'	s
For the right-line tail, - -	·139	7°·9	4°·5	·082	6°·2	5°·0
For the curved tail, - - -	·105	24·2	3·0	·057	24·9	3·9

Allowing for the difference in values of Δ and r, the agreement is quite within the probable errors of observation. It is thus seen that there is great similarity in the physical appearance of the two comets, as well as between the elements of their respective orbits. Since, in general, we have the greatest possible variety in the appearance of the tails of the comets, and especially in the combination of tails of different types, we may confidently say, that the very remarkable similarity above shown furnishes another important fact, in addition to those which already tend to indicate a common origin for the comets of 1807 and 1881.

Sir Isaac Newton and others after him have shown that the tail might be produced by a repulsive force emanating from the sun, and acting on detached particles, which are continually thrown out from the nucleus of all great comets. Bessel has investigated formulæ (Astr. Nachr., vol. xiii) which enabled him to compute the repulsive force necessary to produce a tail of the form actually observed in the case of Halley's comet. The repulsive force in these formulæ is, of course, an implicit function. Bessel's formulæ are shown (Mosc. Ann., vol. v, pt. 2) to give results which are but roughly approximate for large distances from the nucleus. Professor Norton, Dr. Bredichin and others have published formulæ which are more rigorously exact. In all these investigations it is supposed that a particle projected from the nucleus is repelled by a force $(1-\mu)$ the reverse of the Newtonian. The effective force acting on the particle will be μ, and when combined with the tangential velocity of the nucleus will cause it to describe a hyperbolic orbit. This hyperbola will be convex or concave to the sun, according as $(1-\mu)$ is greater or less than unity. In the volumes of the Moscow Annals, Dr. Bredichin presents a variety of reasearches concerning the consequences to be deduced from this assumption of repelling forces.

He refers the tails of comets to three general types, distinguished by the value of $(1-\mu)$ employed in their theoretical representation. The value of $(1-\mu)$ (expressed in the Newtonian unit) for Type I is 11·0 to 12·0; for Type II, about 1·3; for Type III, 0·3, or less. The value of $(1-\mu)$ for Type II, however, is found to vary considerably in different cases without losing its distinctive character. It is possible to introduce the effect due to the initial velocity of projection from the nucleus, and this, of course, modifies the value of $(1-\mu)$ which would otherwise be assumed. This effect will evidently be proportionally least in tails of Type I, and will increase in importance as the value of $(1-\mu)$ is diminished. If we suppose particles to be projected from the nucleus equally in all directions with equal velocities, the effect will be mainly shown in the breadth of the tail. Thus we invariably find tails of Type I to be narrow in comparison with those of Type II,—a fact which finds satisfactory explanation in the relatively small effect, which would be produced by the action of initial velocity, when the repelling force is relatively very great. But since cometary emissions appear to take place mostly on the side of the nucleus nearest the sun, the assumption of the value zero for initial velocity will always render the value of $(1-\mu)$ computed from observation, too small.

It will be interesting to examine our observations of the tail of comet *b* 1881, with a view to determining to what extent they conform to the normal types. In a preliminary discussion like this, which is founded on few observations of small weight, it will not be worth while to include the effect of initial velocity of emission. When a great number of observations of the tail and coma have been collected, it may be possible to arrive at some satisfactory result in this direction. I have accordingly computed the hyperbolic orbits of particles emitted from the nucleus at various times (previous to the observations on the tail), with values of $(1-\mu)$ equal to ·6, 1·0, 1·4 and 11·0. The values of the radius vector and true parabolic anomaly of the nucleus have been computed from the elements of Dr. Oppenheim, previously cited.

Let:

M = Date when a given particle is observed in the tail.
M′ = Time of emission of that particle from the nucleus.
M″ = Perihelion passage of the particle.
E = Eccentricity of the hyperbolic orbit.
I = Angle between the radii vectores of the particle and nucleus at the time M. For the particle referred to the nucleus, this angle will evidently always be retrograde to the motion of the nucleus.
Δ = Distance of the particle from the nucleus at the time, M.

η = Length of perpendicular let fall from the particle on r produced at the time, M.

ξ = Distance from the foot of that perpendicular to the nucleus.

φ = Angle whose sine is $\frac{\eta}{\Delta}$, or the angle between r prolonged and the line joining the nucleus and particle at the time M.

As an example of the manner in which the theoretical lines of Plate VI have been constructed, the results of computations intended to represent the right-line tail of June 26·805 (Berlin time) are subjoined. The value of $(1-\mu)$ is assumed to be 11·0; and the hyperbolical orbits are computed for particles emitted at perihelion, and for two designated dates subsequent to that time. We have:

M′	June 16·510	June 18·510	June 20·510
M″	June 16·510	June 18·359	June 20·205
log E	0·0792	0·0791	0·0788
I	4° 15′	2° 29′	1° 13′
Δ	·284	·192	·110
ξ	·273	·187	·109
η	·077	·041	·018
φ	15°·7	12°·4	9°·5

From the values of Δ, ξ, and η, the curve marked I in the figure for June 26 (Pl. VI) is constructed. From that curve we derive by a graphic process the values of φ corresponding to the observed values of Δ at two points in the tail on that date. We thus have:

		Δ	φ'	φ
June 26·805 Type I	}	·210	12°·9	13°·2
	}	·187	14·0	12·3

The agreement between the values of φ' and φ is even closer than could have reasonably been expected from the unavoidable probable error in the determination of φ'.

In the diagrams of Plate VI, the point N represents the position of the nucleus at the respective times of observation. N R′ is the radius vector prolonged. The curves N I are carefully constructed in the original diagrams from the computed positions of two or more particles, when $(1-\mu)=11·0$. The previous dates of emission were so chosen that one or more computed points would fall near that which was actually observed. The curves N II were constructed with $(1-\mu)=1·4$, and may represent the tail of Type II. The intervals between dates of emission and observation for like values of Δ are much greater in this case than in that for tails of Type I. The curves N II″ are constructed with $(1-\mu)=1·0$; and N III″ for July 22, is based on $(1-\mu)=0·6$. The dots enclosed in small circles indicate the positions of points in the tail actually observed.

The computed positions of these are given in table II. The dotted lines are intended to give a rough idea of the outlines of the tail as observed and reduced to the plane of the orbit, on the somewhat doubtful assumption that the thickness of the tail may be neglected in comparison with its breadth in the plane of the orbit. Following is a tabular view of the results obtained by computation, with the corresponding values from observation.

TABLE III.

Date.	Type I. $(1-\mu) = 11{\cdot}0$.					Type II.					
	Point	Δ	ϕ'	ϕ	$\phi-\phi'$	Point	Δ	ϕ'	ϕ	$\phi-\phi'$	$(1-\mu)$
			°	°	°			°	°	°	
June 26	I_1'	·210	12·9	13·2	+ ·3	II′	·179	29·8	31·2	+1·4	1·4
	I_2'	·187	14·0	12·3	−1·7						
June 28	I′	·161	5·6	11·0	+5·4	II_1'	·189	32·1	32·8	+ ·7	1·4
						II_2'	·153	27·0	29·7	+2·7	1·4
July 1						II_1'	·120	31·3	26·5	−4·8	1·4
						II_2'					
July 22	I′	·082	6·2	5·7	− ·5	II′	·057	24·9	12·	−13·	1·4
									16·	− 9·	1·0
									21·	− 4·	·6

A value of 0·4 for $(1-\mu)$ would give a fair approximation to the tail of Type II as observed on July 22. The agreement of the observed and the computed values of φ for the tail of the first type is very satisfactory. The deviation of five degrees on June 28 might easily be attributed to errors of observation on an object which was so excessively faint; and it is quite probable that the location of the end point was somewhat influenced by the general direction of the tail nearer the nucleus where it was brighter. Such an influence would tend to make the observed value of φ too small. The two values of φ' best determined for Type I are the second and fourth of the table; and these both indicate that a smaller value of $(1-\mu)$ should have been employed.

With reference to the comparisons of observed and computed φ in the tail of the second type, we do not expect an accordance so satisfactory. The difficulties of observation were greater with this branch of the tail, which was broad and faint at its extremity; and, furthermore, an error in location of this shorter branch would have a greater influence upon the value of φ'. The probable uncertainty in the value of φ' for the first three dates I estimate at three or four degrees. On July 22 the location of the shorter branch of the tail was extremely difficult; still I cannot think that the probable uncertainty in φ' is greater than four or five degrees. This would make any value of $(1-\mu)$

much greater than 0·6, extremely improbable for that date, unless we suppose a high velocity of emission from the nucleus mainly on the side nearest the sun. The particles seen near the end of this branch of the tail must have left the nucleus about July 4, and for portions nearer the head at later dates. We know that this period was one of great activity in the nucleus, and it is reasonable to suppose that the velocities of emission toward the sun were unusually great. It is worthy of remark that the value of φ' obtained from Bessel's observation of the 1807 comet (Oct. 22) requires a value for $(1-\mu)$ of about 0·6. (Mosc. Ann., vol. v, pt. 2, p. 56). We may, however, suppose that the matter composing the tail of July 22, having been exposed to a lower temperature at the time of emission than that which prevailed at perihelion, was in a less finely divided state. Then, on the theory of electrical repulsion, we should expect to find a smaller repulsive force for the later date.

On the whole, the results which can be inferred from table III in respect to the ratio of the repulsive forces concerned in the genesis of the two tails, may be regarded as extremely favorable to the hypothesis of Dr. Bredichin, viz: that the tail of Type I is due to the presence of hydrogen in the comet, and that of Type II to carbon. Granting this, we should have expected the traces of hydrogen in the spectrum of the comet to have been very pronounced on June 26, or on dates immediately preceding. On June 28 and for a few days following that date, we might look for a weakening of the hydrogen lines, or, at least, a decided change in the character of that portion of the spectrum. It must be confessed, however, that all reasoning in the premises must necessarily be vague and unsatisfactory, since we do not know to what extent matter, in the state in which it must exist to form the tail, contributes to the spectrum of those parts of the comet in the vicinity of the nucleus and coma, where, alone, spectra have been successfully observed.

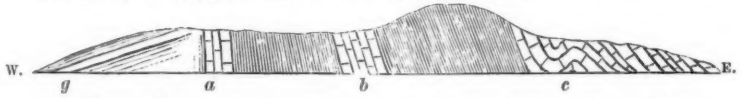
The complete history of this comet, of the changes observed in the nucleus and its surroundings and in the tail, with drawings, measures and estimated dimensions of all parts will be extremely interesting. When collected and combined with results of polariscopic and spectrum analysis, it will doubtless furnish most valuable material bearing upon the true theory of the constitution of comets. That such material exists in rare abundance it is not permitted us to doubt; and it is to be hoped that no one who is in possession of definite results, however meager in quantity, will hesitate to add them to the collection.

Dudley Observatory, September 8, 1881.

Art. XLIII.—*Geological Relations of the Limestone Belts of Westchester County, New York;* by James D. Dana.

1. *Section of the Mott Haven belt of Limestone on 122d St., New York Island.*

As the outcrops of limestone on New York Island will soon be graded away, I here supplement my notice of the 122d street locality with a fuller account of the section there afforded, and a figure representing it. The section is on the north side of this street, and extends from Lexington avenue to the first dwelling house—about 120 feet. There are three belts of limestone: *a*, five feet wide; *b*, seven feet; and *c*, in view to the eastern limit of the open lot, 32 feet. The band *g* looks, at first, as if it were the westward dipping portion of *a*, but it is in reality a seam of granite or granitoid gneiss, in the schist. The three limestone masses *a*, *b*, *c*, appear here to be independent beds. But over the



open lot, thirty yards north of *a*, *b*, the limestone *b* widens *eastward*, or toward *a*, to 25 feet, and only a thin layer of schist separates it from the continuation of *a*; moreover the beds dip eastward under the schist at an angle of only 45°. Forty feet farther north, in the back yard of a house fronting on 123d street (the next north), the western of the bands of limestone widens in both directions, and, from a high westward dip on the west side, bends over eastward to horizontality. From these facts it is probable that *a* and *b* are the two sides of an anticlinal; that this anticlinal has its axis dipping northward, so that the intervening and therefore *underlying* schist disappears to the northward, while the limestone stratum becomes broadly exposed between the overlying schist on the east and west. Some of the schist on the corner of Lexington avenue and 123d street I found to be fibrolitic. On 123d street, only schist is in sight; the middle portion of the area, or that in the direction of the axis of the anticlinal, is occupied by houses. Whether the limestone *c* is the same stratum, brought up by a fault or flexure, or, as it seems to be from its position and thickness, another, I cannot say. If overlying, its continuation would naturally be looked for to the westward, where it is not known to occur. The schist is much rusted and its bedding poorly exposed: moreover, the outcrops of limestone south of 122d street differ widely from those on its north side; and for these reasons it is difficult to reach any positive stratigraphical conclusions.

This locality is on the western border of the Mott Haven limestone belt. As to the eastern border, nothing is here indicated, beyond this, that the limestone increases in amount to the eastward.

Mr. Stevens's figure of the section on 122d street, in the Annals of the New York Lyceum, referred to on p. 432 of the last volume of this Journal, is so very unlike what I have found at the place, and agrees in so many points with that of the more western belt on 132d street, of which also he speaks in the article, that I have suspected it to be wrongly labelled.

2. *Contact-phenomena in the Schist and Soda-granite of Cruger's and Stony Point.*

In my remarks on the rocks at Cruger's and Stony Point I have sustained the view that the contact-phenomena, as they may in a literal sense be called, between the mica schist and soda-granite, are not results of contact of the schist with a pasty or liquid rock. I add here a few more words on this point.

The contact-phenomena are these. The mica schist changes, over the interval of about 1,000 feet between the limestone stratum on the south and the granite on the north, (1) from a nearly even-bedded condition to a much-flexed one—it becoming bent up to the northward in many places into close and deep zigzags; (2) from a finely crystalline state to a coarsely crystalline—in connection with which change there is an increase in the size and abundance of garnets; (3) from a garnetiferous mica schist, to a staurolitic and fibrolitic mica schist, with also an increasing abundance of garnets; (4) from a near freedom from quartz seams to a condition of crowded interlamination with them; and (5) occasionally, near the granite, from its ordinary micaceous and quartzose character to a feldspathic and gneissoid, in which oligoclase occurs with the orthoclase and the constitution thus approaches that of the granite. Besides the above, the granite often contains (6) scattered garnets near the junction, and also (7) both near and remote from the schist, numerous inclusions of schist, many of them short fragments, others long, flexed, or zigzag layers, parallel in position to the bedding of the schist outside, some fading nearly into the granite and vein-like, others, especially if staurolitic, having all the characters of such layers in the outside schist.

The following considerations are believed to confirm the correctness of the conclusion to which I have been led as to the origin of these contact-phenomena.

(1) The zigzag flexures of the mica schist—a rock of great firmness, rendered eminently so by its numerous quartzose interlaminations—must have been made at the time when its metamorphism took place; for their production after it was in its solid crystalline condition would be impossible, or, at least so without its having every where evidence of fracturing.

(2) The zigzag and other flexures in the schist indicate that great pressure was exerted from some direction against the stratum of slate (and other strata of the series) under conditions fitted to produce them. A yielding liquid or pasty rock, however forcibly intruded, would be a very feeble agent for such work, and would have afforded feeble resistance to pressure from other agencies.

(3) The increase in the grade of metamorphism, sufficient moisture being present, would have needed no other cause but an increase in the degree of heat; and this would have been, in any case, a consequence of the increasing extent of the flexures or of internal movements in the schist; for the constituent minerals consist only of the common ingredients of sediments, and increase in abundance of garnets means little more than increase in amount of iron.

(4) Staurolite and fibrolite are minerals that occur widely distributed through mica schists; and require for their formation, not contact-conditions, but too little alkali with the silica and alumina in the original bed-material to make a feldspar.

Whatever, then, the origin of the granite, the schist must have been put into its present flexed condition before there was any liquid or pasty rock in front of it. Further, whatever the schist has of crystallization or of crystallized minerals may have been produced independently of any such condition. Finally, the above facts, and others mentioned under the head of contact phenomena showing transitions between the two rocks, are opposed to the idea that the granite is of exotic eruptive origin, and are well explained on the view of simultaneous metamorphic changes in two adjoining conformable sedimentary formations that had some intermediate gradations and intercalations, in which the granite-made portion passed to a pasty state and so became in some places an intrusive rock.

The mica schist and the adjoining limestone are strata in a great synclinal or anticlinal fold, and probably, as I have shown, the former. But whether the fold be a synclinal or anticlinal, the increase northward observed in the zigzag flexures and in the metamorphism is *increase toward the axial plane of the fold.* The minor zigzag flexures may have been the effect either of the pressure that produced the great fold, or of the gravitation of the mass after it had been raised to a high angle—now 70°.

The facts at Stony Point are very similar to those at Cruger's. Although in some points seeming to sustain quite strongly the theory of direct eruptive origin, if viewed together with those of Montrose Point and the Verplanck Peninsula, they lead, I believe, to the same conclusion—that of a metamorphic origin alike for the soda-granite, quartz-dioryte, noryte and chrysolitic rocks. If there has ever been an example of an igneous rock made through the fusion of sedimentary beds, the cases above described may be reasonably regarded as of this mode of origin.*

For the remainder of this Appendix see the supplementary sheet at the close of this number, p. 327.

* One of the statements on page 201 of the article referred to I have to withdraw—that relating to figure 4. The figure is correct as far so it goes: but I have found, on a recent visit to the place, that the band is continued after another fault, and is not a narrower one folded on itself.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Velocity of Light.*—Lord Raleigh discusses the recent paper of Young and Forbes (Roy. Soc. Proc., May 17, 1881), in which it is maintained that blue light travels *in vacuo* about 1·8 per cent faster than red light, and asks the question: what is really determined by observations on the velocity of light? Is the velocity of a single wave determined, or that of a group of waves? If the group velocity be denoted by U and the wave velocity by V, the relation between these velocities is explained by $U=\frac{d(kV)}{dk}$, in which k is inversely proportional to the wave length. According to Young and Forbes, V varies with k and therefore U and V are different. A complete knowledge of U, which can be obtained by experiment, does not lead to a knowledge of V. Lord Rayleigh discusses the various methods employed in determining the velocity of light and concludes that if we regard the solar parallax as known, we obtain almost the same velocity of light from the eclipses of Jupiter's satellites as from observation, although the first result relates to the group velocity and the second to the wave velocity. There cannot be, therefore, a difference of two or three per cent between the group velocity and the wave velocity. These considerations lead Lord Rayleigh to doubt the conclusions of Young and Forbes.—*Nature*, Aug. 25, 1881, p. 382. J. T.

2. *Movement of Sound Waves in Organ Pipes.*—Dr. Rudolph Koenig has contrived an ingenious arrangement which enables one to observe the nodes and segments of a sound wave in its passage through an organ pipe. The pipe is slotted along its entire side, is then placed in a horizontal position with the slot beneath and resting in a trough of water. The water thus forms a portion of the lower side of the pipe and the slot allows a hollow glass tube, U-shaped, to be pushed along the interior throughout its entire length. By connecting the glass tube with manometric capsules, one can discover the position of the nodes and also observe peculiarities in the movements of the waves.—*Ann. der Physik und Chemie*, No. 8, 1881. J. T.

3. *On the Conductivity of Metals for Heat and Electricity.*—In the continuation of a paper on this subject, Herr L. Lorenz discusses the theoretical laws of the cooling of metals when placed in ordinary air and extends his observations to the conduction of heat by metals in general. If T represents the absolute temperature, k and $\varkappa$ the conductivity for heat and electricity respectively, he is led to the following expression: $\frac{k}{\varkappa}=T\times$ constant. According to his view there is discontinuity in the interior of every body and there are regions or sections along which free electricty can move without manifesting difference of

potential or experiencing resistance. When the electricity passes through these regions, electric potential is observed. The heat state and the electrical state are interconvertible forms of energy, manifested according to the state of the body.—*Ann. der Physik und Chemie*, No. 8, 1881, p. 582. J. T.

4. *Microphonic action of Selenium cells.*—Dr. JAMES MOSER, led by the theory that one and the same ray of light may have heating, chemical and luminous effects, has examined the behavior of selenium under the influence of the electrical current. It was found that ordinary electrical polarization was manifested by selenium: with a cell composed of zinc, selenium and copper, a polarization of about 0·4 volt. was observed and a current was obtained long after it was separated from the primary battery. A careful examination of the connections between selenium and copper in the form of cells invented by Bell and Tainter, and modified by others, showed that between the copper and the selenium there is only a slight and imperfect contact. Moser therefore concludes that the selenium photophone is a microphone, and is confirmed in this belief by the action of the carbon photophone constructed by Bell and Tainter, which consists of a zigzag line scratched on a silver covered glass plate and covered with lamp-black. This instrument acts like the thermoscope described by Mr. Hughes. The illuminating rays of light are those which are especially absorbed by selenium, "only the absorbed rays can produce changes of volume and of shape and in this way influence the contact of current-conducting parts." Selenium, therefore, is heated by light and this heating effect makes the selenium cell act microphonically. The light may also produce certain chemical effects in the interior of the selenium, which may contribute to the efficiency of the cell. It was found that the resistance of certain pieces of selenium increased instead of decreased when submitted to light. Dr. Moser therefore sees no reason for separating selenium from other bodies and "no prospect of finding an unknown power or a new relation of forces in this substance."—*Phil. Mag.*, Sept., 1881, p. 212. J. T.

5. *On the stresses caused in the Interior of the Earth by the Weight of Continents and Mountains;* by G. H. DARWIN, F.R.S. —In this paper I have considered the subject of the solidity and strength of the materials of which the earth is formed from a point of view from which it does not seem to have been hitherto discussed.

The first part of the paper is entirely devoted to a mathematical investigation, based upon Sir William Thomson's well-known paper on the rigidity of the earth.* The second part consists of a summary and discussion of the preceding work.

The existence of dry land proves that the earth's surface is not a figure of equilibrium appropriate for the diurnal rotation. Hence the interior of the earth must be in a state of stress, and as the land does not sink in, nor the sea-bed rise up, the materials

* "Thomson and Tait's Nat. Phil.," § 834, or "Phil. Trans.," 1863, p. 573.

of which the earth is made must be strong enough to bear this stress.

We are thus led to enquire how the stresses are distributed in the earth's mass, and what are magnitudes of the stresses.

In this paper I have solved a problem of the kind indicated for the case of a homogeneous incompressible elastic sphere, and have applied the results to the case of the earth.

If the earth be formed of a crust with a semi-fluid interior, the stresses in that crust must be greater than if the whole mass be solid, very far greater if the crust be thin. As regards the condition of incompressibility attributed to the materials of the earth, it is proved in this paper that the compressibility of the solid would make no sensible difference in the results; except, indeed, in the case where the deformation of the sphere is of the second spherical harmonic class, when large compressibility would considerably modify the results.

The strength of an elastic solid is here estimated by the difference between the greatest and least principal stresses, when it is on the point of breaking, or, according to the phraseology adopted, by the breaking stress-difference. The most familiar examples of breaking stress-difference are when a wire or rod is stretched or crushed until it breaks; then the breaking load divided by the area of the section of the wire or rod is the measure of the strength of the material. Stress-difference is thus to be measured by tons per square inch.

Tables of breaking stress-differences for various materials are given in the paper.

The problem is only solved for the class of inequalities called zonal harmonics; these consist of a number of waves running round the globe in parallels of latitude. The number of waves is determined by the order of the harmonic. In the application to the earth the equator here referred to may be any great circle, and is not necessarily the terrestrial equator. The second harmonic has only a single wave, and consists of an elevation at an equator and depression at the pole; this constitutes ellipticity of the spheroid. An harmonic of a high order may be described as a series of mountain chains, with intervening valleys, running round the globe in parallels of latitude, estimated with reference to the chosen equator.

The case of the second harmonic is considered in detail, and it is shown that the stress-difference rises to a maximum at the center of the globe, and is constant all over the surface. The central stress-difference is eight times as great as the superficial.

On evaluating the stress-difference arising from given ellipticity in a rotating spheroid of the size and density of the earth, it appears that if the excess or defect of ellipticity above or below the equilibrium value were $\frac{1}{1000}$, then the stress-difference at the centre would be 8 tons per square inch; and that, if the sphere were made of material as strong as brass, it would be just on the point of rupture. Again, if the homogeneous earth, with ellipticity $\frac{1}{232}$, were to stop rotating, the central stress-difference would be

33 tons per square inch, and it would rupture if made of any material excepting the finest steel.

The stresses produced by harmonic inequalities of high orders are next considered. This is in effect the case of a series of parallel mountains and valleys, corrugating a mean level surface with an infinite series of parallel ridges and furrows.

It is found that the stress-difference depends only on the depth below the mean surface, and is independent of the position of the point considered with regard to ridge and furrow.

Numerical calculation shows that if we take a series of mountains, whose crests are 4000 meters, or about 13000 feet, above the intermediate valley bottoms, formed of rock of specific gravity 2·8, then the maximum stress-difference is 2·6 tons per square inch (about the tenacity of cast tin); also if the mountain chains are 314 miles apart, the maximum stress-difference is reached at 50 miles below the mean surface.

The solution shows that the stress-difference is *nil* at the surface. It is, however, only an approximate solution, for it will not give the stresses actually in the mountain masses, but it gives correct results at some three or four miles below the mean surface.

The cases of the harmonics of the 4th, 6th, 8th, 10th, and 12th orders are then considered; and it is shown that, if we suppose them to exist on a sphere of the mean density and dimensions of the earth, and that the height of the elevation at the equator is in each case 1500 meters above the mean level of the sphere, then in each case the maximum stress-difference is about 4 tons per square inch. This maximum is reached in the case of the 4th harmonic at 1150 miles, and for the 12th at 350 miles, from the earth's surface.

In the second part of the paper it is shown that the great terrestrial inequalities, such as Africa, the Atlantic Ocean, and America, are represented by an harmonic of the 4th order; and that, having regard to the mean density of the earth being about twice that of superficial rocks, the height of the elevation is to be taken as about 1500 meters.

Four tons per square inch is the crushing stress-difference of the average granite, and accordingly it is concluded that at 1000 miles from the earth's surface the materials of the earth must be at least as strong as granite. A very closely analogous result is also found from the discussion of the case in which the continent has not the regular wavy character of the zonal harmonics, but consists of an equatorial elevation with the rest of the spheroid approximately spherical.

From this we may draw the conclusion, that either the materials of the earth have about the strength of granite at 1000 miles from the surface, or they have a much greater strength nearer to the surface.

This investigation must be regarded as confirmatory of Sir William Thomson's view, that the earth is solid nearly throughout its whole mass. According to this view, the lava which issues

from the volcanoes arises from the melting of solid rock, existing at a very high temperature, at points where there is a diminution of pressure, or else from comparatively small vesicles of rock in a molten condition.—*Proc. Roy. Soc.*, June, 1881.

6. *Expansion of Cast Iron while solidifying.*—M. J. B. Hannay and Robert Anderson have a paper on this subject in the Proceedings of the Royal Society of Edinburgh for December, 1879 (p. 359). By trials in different ways, the authors reach the conclusion that "liquid cast iron expands at least 5·62 per cent of its volume on freezing."

II. Geology and Natural History.

1. *Origin of the Iron Ores of the Marquette District, Lake Superior;* by M. E. Wadsworth. (Proc. Boston Soc. Nat. Hist., xx, 470, March, 1880.)—After a few prefatory sentences, this paper presents what are regarded as objections to the view of the *metamorphic* origin of the Archæan iron ores of Marquette, and a brief mention of reasons for holding that of its *eruptive* origin. The argument for their metamorphic origin, from the fact that the ore is banded, conformably to the outside schists, with layers of red jasper, and is often schistose in the same direction, is met by the remark that this banding is strongly like the banding of some rhyolites, thus making banding a character of more importance than mineral constitution. To the argument for metamorphism from original marsh-made beds, based on the fact that the ore is in bed-like masses conformable with the bedding of the associated schists, the author says—putting his objections in the unnecessary, but with him common, form of ridicule, and shooting wide of the real point at issue—that whoever advanced this theory "probably intended it for a bit of facetiousness." "A dike passing through slate must be sedimentary because the slate is sedimentary! Do we not find rocks intruded through sedimentary ones in every position, both parallel with the stratification and oblique or perpendicular to it?" and then, with still more earnestness in his misdirected logic, "Can any geologist ever have been so ignorant of the mutual association of eruptive and sedimentary rocks as to have soberly advanced the above idea?" After discussing in this style "all the evidence which we are aware has been used to prove the sedimentary origin of the jaspilite and ore," Mr. Wadsworth uses a still more personal method, the notice of which is unnecessary.

Mr. Wadsworth, in his argument for an *eruptive* origin, which follows, does not show that the iron ore and jasper are much like eruptive rocks in mineral constitution, or give facts proving that iron sesquioxide and silica, among the most infusible of minerals, may come up side by side in a state of fusion, when ordinary ejected rocks contain the iron and silica chiefly in fusible combinations; he simply asserts, "as the prominent fact," "that wherever the contact of these rocks with the country rock could be studied, that contact was always an eruptive one," of

which he says he is especially able to judge. There is nothing else of as much importance as this, and on this point his inference is not confirmed by the writer's microscopic examination of thin slices of the jasper and adjoining ore. No detailed facts or sections, or descriptions of rock-slices, are given; the deficiency of the article in this respect is one of its remarkable features. The author, after depreciating remarks about others, mentions, in his paper, the several qualifications,—geological, lithological, petrological, etc.,—required for the model investigator of the subject; and, in contrast, the paper itself contains no geological, lithological, or petrological details.

The paper closes with a statement of the author's ideas as to scientific progress, part of which we cite, that the warning it conveys may be circulated and duly heeded: "The day seems not so far distant as might be supposed, when it will again be as necessary to challenge the statements of those holding plutonic views as it is now those holding neptunian ones. The popular belief in any subject continually oscillates between different opinions like a mighty pendulum, passing and repassing the point of truth. But, strange fatality, if it stops at this point, all is stopped, the works are dead. When truth is reached or discussion ends, stagnation ensues. Again, when the pendulum vibrates, woe be to the man who swings not with it. In all candor we ask geologists to stop and think if the pendulum has not swung decidedly out of the perpendicular on the sedimentary side? Ease up a little, brethren, but do not swing back too far."—A head not out of the perpendicular is plainly very desirable. J. D. D.

2. *The Taconic rocks of the border of Lake Champlain.*—Mr. Jules Marcou has an important paper in the Bulletin of the Geological Society of France for Nov. 8, 1880 (III, ix, No. 1, 1881), on the rocks of the northeastern border of Lake Champlain, referred by Emmons to the Taconic System, and especially upon what he regards as "colonies" in these rocks, using the term nearly as done by Barrande, for "centres d'apparition d'êtres précurseurs et de types prophétiques." These Taconic slates have in part been referred, since Barrande's article on the fossils, to the Primordial or Cambrian. The paper gives in detail the results of Mr. Marcou's study of the beds near Georgia, St. Albans, Swanton and Highgate Springs, and illustrates his conclusions on a colored geological map, and also by means of a large plate of sections, which, together, will be of much service to future students of the region. The Taconic rocks are stated to be older than, and also unconformable to, the Potsdam sandstone. The apparent unconformabilities were explained by Logan on the ground of faults and displacements (Geol. of Canada, 1863, pp. 844–861), and this has since been the generally accepted view. But Mr. Marcou reaches different conclusions, and, by means of the idea of colonies, rids the subject, to his satisfaction, of adverse paleontological evidence. The Georgia slates contain the Primordial trilobites. He describes, as next above, the Phillipsburgh group, and this as passing above into the Swan-

ton group, and both series of slates as including lenticular masses or beds of limestone. These limestone masses contain the colonies, and from the fossils they afford he concludes—taking one of his lines of limestone beds as an example—that Billings's species *Lituites Farnsworthi*, *L. Imperator*, *Nautilus Pomponius*, *Murchisonia Vesta*, *Metoptoma Niobe*, *M. Orithya*, *Pleurotomaria postuma*, *Maclurea matutina*, *M. ponderosa*, *Ecculiomphalus Canadensis*, *E. intortus*. and *E. spiralis*, are part of the American *Primordial* fauna; and to the same category he refers also, for a like reason, species of *Asaphus*, *Cheirurus*, *Calymene*, *Illœnus*, *Trinucleus*, *Rhynchonella*, *Murchisonia*, etc. Thus the precursor species are the *actual* species of the later Lower Silurian, colonized in the remote Cambrian before the era of the Potsdam sandstone. This application of the idea of colonies makes a jumble of the early Paleozoic of America, instead of indicating the way out from difficulties in certain regions of faulted and flexed metamorphic rocks. No such scheme can take from Calciferous, Chazy and Trenton fossils their value as tests of geological age, even if the question as to the Taconic slates is involved therewith, unless it first be substantiated by the study of the fossils in undisturbed strata.

3. *Volcanic Eruption on Hawaii.* A letter from the Rev. Titus Coan to one of the editors, dated Hilo, Aug. 24, 1881.—The stream of lava continued until it had reached within one mile of the sea, and three-fourths of a mile of a well-peopled part of Hilo. All at once the flow seemed to be checked, and, by the 10th of this month, little or no vapors were seen along its channel, or high up on the broader part of the stream, or about the summit of the burning mountain. The blackened lavas of the eruption cover about two square miles to an average depth of twenty-five feet; but this is only a rough estimate for no exact measurements have as yet been made. We judge the length of the third stream to be fifty miles, including all its deflections, and for the most of this distance it was, to all appearance, a surface stream.

4. *Glacier Scratches in Goshen in Northwestern Connecticut.*—Glacier scratches over the higher portions of New England are of special interest because they give the direction of movement in the ice free from the swervings due to the courses of valleys. The higher lands of Goshen are particularly favorable in this respect. Observations have been recently made by Mr. Henry Norton, of Winsted, which we here cite.—On the west side of the mountain (allowance having been made for magnetic variation), S. 41° E., but with one deep one, S. 77° E.; farther south, in Mr. McElhane's lot, several deep groovings S. 38° E.—and pointing, northwestward, directly toward Mt. Everett; south of the house, on the same lot, S. 22¾° E. and S. 58° E.

5. *On the Structure and Affinities of the Genus Monticulipora and its Subgenera, with critical descriptions and illustrative species;* by H. Alleyne Nicholson, Prof. Nat. Hist. Univ. St. Andrews. 240 pp., large 8vo, with six plates and many wood cuts. 1881. Edinburgh and London. (Wm. Blackwood & Sons.)—This vol-

ume, while not, as the author says, a monograph of this group of fossil corals, contains a historical and critical review of previous memoirs and conclusions on the subject, a discussion of the synonymy as to genera and species; explanations of microscopic structure; inferences as to the affinities and zoological position of the genus, and descriptions of several new species. The observations are based mainly on specimens collected in the United States and Great Britain. The volume bears evidence of much study and research in its preparation, and of liberal expenditure by the publishers in its manufacture, and will be welcomed especially by American paleontologists.

6. *Ulexite in California;* Note by W. P. Blake. (Communicated.)—Ulexite occurs in quantity in Kern County, California, in the bed of an extensive "salt marsh," a few miles north of Desert Wells, and twenty miles from Mojave Station on the railway.

7. *Worked Shells in New England Shell-Heaps;* by Edward S. Morse.—Mr. Morse called attention to the fact that heretofore no worked shells had been discovered in the New England shell-heaps. A similar absence of worked shells had been noticed in the Japanese shell-heaps. Worked shells were not uncommon in the shell-heaps of Florida and California. Mr. Morse then exhibited specimens of the large beach cockle (Lunatia) which showed unmistakable signs of having been worked. The work consisted in cutting out a portion of the outer whorl near the suture. To show that this portion could not be artificially broken he exhibited naturally broken shells of the same species, both recent and ancient, in which the fractures were entirely unlike the worked shells.—*Abstract of paper read before the Amer. Assoc. at Cincinnati.*

8. *Changes in Mya and Lunatia since the deposition of the New England Shell-Heaps;* by Edward S. Morse.—This communication embraced a comparison between the shells peculiar to the ancient deposits made by the Indians along the coast of New England, and similar species living on the coast at the present time. He referred to similar comparisons which he had made in Japan, wherein he had found marked changes to have taken place; changes which showed that the proportions of the shells had greatly altered.

He had made a large number of measurements of shells from a few shell-heaps of Maine and Massachusetts, and had obtained very interesting results. The common clam (Mya) from the shell-heaps of Goose Island, Maine, Ipswich, Mass., and Marblehead, Mass., in comparison with recent forms of the same species, collected in the immediate vicinity of these ancient deposits, showed that the ancient specimens were higher in comparison with their length than the recent specimens.

A comparison of the common beach cockle (Lunatia) from the shell-heaps of Marblehead, Mass., showed that the present form had a more depressed spire than the recent forms living on the shore to-day, and this variation was in accordance with observations he had made on a similar species in Japan.—*Ib.*

9. *Beiträge zur Morphologie und Physiologie der Pilze, Vierte Reihe;* by A. DeBary and M. Woronin.—After an interval of not far from ten years, the important series of papers by DeBary and Woronin, published under the above title in the Abhandl. Senckenb. Gesellsch., is continued in a fourth part which contains a paper by DeBary on *Investigations on the Peronosporeæ and Saprolegnieæ and the formation of a Natural System of Fungi.* The article covers 137 quarto pages, with six lithographic plates. The subject is treated under sixteen different heads, of which the first twelve are devoted to an account of different forms of *Pythium*, *Phytophthora*, *Peronospora*, *Saprolegnia*, *Achlya* and *Aphanomyces*. With the exception of some hitherto undescribed species, the writer has confined himself principally to the changes which occur in the formation of the oogonia and antheridia, giving with great minuteness the details of the process of fertilization. In the genera like *Pythium* and *Peronospora* where only one oospore is produced in an oogonium, the oospore is separated from the oogonium wall by a layer of protoplasm to which DeBary gives the name of periplasma, and he thinks that the markings formed on the outer coat of certain oospores is formed directly from the periplasma, and is not an exudation from the cellulose wall of the spore itself. In *Pythium* a small process, or befruchtungsslauch, penetrates the oogonium wall, and reaches the oospore. In this process DeBary distinguishes a thin homogeneous layer lining the wall, which he calls periplasma, while to the thicker axial portion he gives the name of gonoplasma. The act of fertilization consists, in *Pythium*, of the escape of the gonoplasma through the open end of the process and its union with the oospore. In *Phytophthora* and *Peronospora* during the act of fertilization some of the contents of the antheridium pass apparently into the oospore, but the transfer is by no means as marked as in *Pythium*, and the matter which escapes from the antheridial process consists of only a few granules and the whole axial portion does not escape as in *Pythium*.

In *Saprolegnia* and *Achlya* nothing could be seen to be discharged from the antheridial tubes and the fertilization consists merely in the contact of the male filaments with the surface of the oospores. Contrary to the view advanced by Pringsheim, DeBary finds that the thin spots in the oogonium walls of some species, and the papillæ found in others, have no direct connection with the antheridial tubes which may penetrate the oogonium walls in any place. It has long been known that in some of the *Saprolegneæ*, oogonia are found in which the oospores apparently ripen, although antheridia are wanting. It has been suggested that in such cases antheridia were actually present but had been overlooked. DeBary agrees with Pringsheim in affirming that in some cases oospores ripen without the presence of antheridia. He differs with Pringsheim, however, in considering such forms to be distinct species rather than accidental variations of species in which antheridia normally occur. He does not deny that forms

with antheridia and forms without them may have originally been derived from a single species, but cultures continued for two years showed that forms without antheridia constantly reproduced themselves, and they are, according to DeBary, instances of apogamous reproduction.

The fifteenth section treats of the systematic position of the *Peronosporeæ* and *Saprolegnieæ*. In the former order is included *Pythium*. The last section, to which, in a certain sense, all the others are merely introductory, is a valuable discussion of the relation of the different orders of fungi to one another, and to some extent of the algæ. Apparently, DeBary is not willing to go as far as Sachs in giving up the general distinction of algæ and fungi, although recognizing their close relationship. Starting with the *Peronosporeæ*, he considers that a series can be formed, on the one hand, by that order, the *Ascomycetes*, and the *Uredineæ*, the last named order being connected with the *Basidiomycetes* by the *Tremellini*. A second series is formed by the *Saprolegnieæ*, *Chytrideæ* and *Ustilagineæ*. With regard to the sexuality of Fungi, DeBary expresses himself in rather a conservative manner and considers that in some cases, as in certain *Ascomycetes*, sexual reproduction seems to be out of the question, and he is inclined to regard the spores in several groups to be of apogamous origin.

W. G. FARLOW.

10. *Fauna und Flora des Golfes von Neapel; IV Monographie: Corallina;* by Professor SOLMS-LAUBACH. Leipzig, 1881.—This small folio of 64 pages with three lithographic plates is the first botanical contribution which has been issued in the form of a separate memoir, although several botanical papers have appeared in the Mittheilungen of the Zoological Station at Naples, and Reinke has published two papers on the *Cutleriaceæ* and *Dictyotaceæ* of the Bay of Naples in the Nova Acta. Twenty pages are devoted to an enumeration of the Corallines in the region of Naples; including five genera, and twenty-five species. The specific account is followed by a chapter on the conformation of the organs of vegetation as a basis of generic distinctions. It is incidentally stated that the so-called heterocysts described by Rosanoff in *Melobesia farinosa* are really the spots from which hairs are given off, and according to Solms they are found also in *M. callithamnioides* and *Lithophyllum insidiosum*. The third chapter contains a minute account of the development of the fruit of *Corallina mediterranea*, with notes with regard to the fruit in some other species. The present writer does not accept the account given by Thuret of the difference in the cystocarps of *Corallina* and *Jania* but unites the two genera. In regard to the spermatozoids he maintains in opposition to Thuret that they are not naked but have a distinct wall comparable to that of the spermatia of fungi. The spores are borne on what Solms calls a fusion-cell, a structure found in all the order examined. The closing chapter has observations on the fructification of *Amphiroa*, *Melobesia*, *Lithophyllum* and *Lithothamnion*. An interesting account is given

of the thallus and fruit of *M. Thuretii*, the curious parasite on species of *Corallina*, and a similar parasite, *M. deformans*, is described by Solms from Australia. A formation of gemmæ, not elsewhere known in the order, is described and figured in *Mel. callithamnioides.* W. G. F.

11. *The Botanical Collector's Handbook;* by W. WHITMAN BAILEY. (G. A. Bates, Salem.)—This volume forms number three of the Naturalist's Handy Series, and contains full directions for the collection of all kinds of plants and their proper preparation for, and the arrangment in the herbarium. The writer has been aided in his account of the method of collecting cryptogams, by notes from experts in different departments, and there is a chapter by Mr. C. H. Peck on the preparation of fungi. At the end is a short account of the principal public herbaria in this country and a list of books relating to the floras of different countries. The book is illustrated by wood-cuts. W. G. F.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Ancient Japanese Bronze Bells;* by EDWARD S. MORSE.—Mr. Morse described the so-called Japanese bronze bells which are dug up in Japan. These bells had been described and figured by Professor Monroe in the Proceedings of the New York Academy of Sciences. Mr. Kanda, an eminent Japanese archæologist had questioned their being bells from their peculiar structure. Mr. Morse had seen a number of different kinds of bells, some of considerable antiquity, but none of them approached these so-called bronze bells. Mr. Kanda had suggested that they were the ornaments which were formerly hung from the corners of pagoda roofs. But the fact that none of them showed signs of wear at the point of support, rendered this suggestion untenable. Mr. John Robinson, of Salem, the author of a work on Ferns, had given the first suggestion as to the possible use of these objects. He had asked why they may not have been covers to incense burners.

Curiously enough old incense burners are dug up which have the same oval shape that a section of the bell shows. The bell has openings at the base and also at the sides and top, so that the smoke of burning incense might escape. It is quite evident that these objects are neither bells nor pagoda ornaments and this suggestion of Mr. Robinson's may possibly lead to some clue regarding their origin.—*Abstract of paper read before the Amer. Assoc. at Cincinnati.*

Primitive Industry, or Illustrations of the Handiwork in Stone, Bone and Clay of the Native Races of the Northern Atlantic Seabord of America, by Charles C. Abbott, M.D. 560 pp., with many illustrations. Salem, Mass., 1881. (George A. Bates).—A notice of this excellent work, and also of the following, is deferred to another number.

Report on the Geology and Resources of the Black Hills of Dakota, by H. Newton and W. P. Jenney: U. S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. Powell in charge. 566 pp. 4to., with plates and a folio atlas. Washington, 1880.

APPENDIX.

ART. XLIV.—*Appendix to Paper on the Geological Relations of the Limestone belts of Westchester County, New York;* by JAMES D. DANA.*

3. *The rocks and their observed positions in Westchester County and New York Island.*

IN the following notes, the abbreviations used are: Av. Avenue; St., Street; calc., calcareous; *l.* limestone; *gn.*, gneiss (variety without excess of mica); *thin gn.*, thin schistose gneiss; *m.* micaceous, mica; *m. gn.*, micaceous gneiss; *m. sch.*, mica schist; *hard gn.*, hard or compact thick-bedded gneiss; *hbl.*, hornblende; *hblc.*, hornblendic; N., north; S., south; E., east; W., west; R., river; R.R., railroad; var., varying. In giving the strike and dip, the words strike, dip, are omitted; N. 20° E., 70° E. signifies strike N. 20° E., dip 70° to the eastward, and so throughout. As heretofore, the courses are corrected for magnetic variation. The courses and dip given are those corresponding to the T-symbols on the maps at the places mentioned; and where there is no T-symbol on the map, the course and dip is put in brackets. The maps referred to are that of Westchester County in volume xx, numbered Plate V, and that of Westchester County and northern New York Island, in volume xxi, numbered Plate xix.

1. ON NEW YORK ISLAND.

A. EAST OF 4TH AVENUE.—W. of 3d Av., 100 yds. from 4th, on 102d St., *gn.* and *m. gn.* N. 40° E., 90°, 80°–70° E., and again 70 yds. from 4th Av., on 102d St., N. 46° E. (varying), 80° E.; S.W. corner of 3d Av. and 103d St., *m. gn.* N. 22°–39° E., 70°–80° E., 90°, 80° W. to 60° W.; cor. Lexington Av. and 103d St., *m. gn.* N. 38° E., 65° E., N. 39° E., 85° E., with a twist to E. and W., and dip S. of 60°, much *hblc.* where beds most contorted.

Near 123d St. and Av. A, on East River, *m. gn.* N. 26° E., 60° W., the outcrop under water at high tide.—N.W. corner 120th St. and Lexington Av., *m. gn.* N. 26°–28° E., undulating; 122d St., E. of Lexington Av., N. side of St., *l.* N. 26°–28° E., 90°, 70°–45° E.; in E. part of open lot, bending to N. 55° E, (see above); [On 123d St., northeast part of same open lot *m. sch.* N. 31° E., 80° E.]; [W. side of Lexington Av., S. of 124th St., N. 26° E., 70°]. E. side of 4th Av., S. of 118th St., *l.* in *m. gn.* N. 27°–32° E., 90°, 80° W. S.E. corner of 130th St. and 4th Av., *m. sch.* and *gn.*, N. 26° E., undulating, dip 0°–90°, mostly 50°–70°.

B. BETWEEN 4TH AND 6TH AVENUES.—W. of 4th Av., on 102d St., S. side, *m. gn.* N. 21° E., contorted, 90°, 70° W., N. side 50 yds. from Madison Av., N. 29° E, 70°–80° W.; N. of 117th St., between Madison Av. and 4th Av., *gneissic l.* N. 28° E., 70°–50° E.; W. of Madison Av., *m. gn.* horizontal and undulating; W. of W. corner of 5th Av. and 120th St., S. of Mt. Morris Park, garnetif. *m. gn.*

* This paper is contained in volumes xx to xxii of this Journal.

N. 28° E., 50°–65° W.; 120th St., S. of S.W. angle of same Park, 400 feet E. of corner, *m. gn.* N. 17°–22° E., 45° E., and 250 feet E. of corner, 50°–70° W.; W. of 4th Av., either side of 120th St., *m. gn.* contorted, N. 27° E., undulating, and S. of 125th St., *m. gn.* N. 26° E., 65°–70° E.

In Mt. Morris Park, *m. gn.* N. 30°–32° E.; N. 30°–34° E.; 60°–70° E.; N. 45° E., 60°–70° E.; [also in S. part, fronting 5th Av., *m. gn.* N. 30° E., 75°–80° E., also in zigzags].

Between 131st St. and 133d St., N. side of 132d St., *l.* N. 20°–28° E., dip undulating, E. and W. but mostly E., and S. side of 132d St., *l.* over open lot and half way to 131st St., N. 24°–28° E., 90° or nearly; and to E. *m. sch.* N. 23°–32° E. (28° average), undulating, large contortions.

C. Between 6th and 8th Avenues.—In Central Park N. 32°–27° E., 70°–75° E., but much contorted. Along 7th Av., at S.E. corner of 138th St., *m. gn.* N. 34° E., 70° E.; near 139th St., N. 37° E., 65°–70° E.; 140th St., N. 30° E., 70° E.; near 145th St., N. 26° E., 80° E.; N. of 149th St., N. 26°–28° E., 80°–85° E.; [also, near 154th St., *gn.* and *m. gn.* N. 31°–33° E., 70°–80° E., 90°].

D. Between 8th and 10th Avenues, South of 155th Street.—On 9th Av., near 104th St., *m. gn.* N. 29° E., 10°–60° E.; E. of 9th Av. on 110th St., N. 27°–32° E., 80° E.; W. of 9th Ave. on 110th St., *m. gn.* N. 34° E., 80°–90°, contorted and much *hblc.*

East side of rocky part of Morning Side Park in line of 115th St., *m. gn.* N. 22°–29° E., 65° W.–90°, *hblc.* layers; same, farther N., nearly to line of 117th St., N. 37°–40° E., 60°–75° E., large slabs cleaved off and slid down the bluff; [same, in line of 117th St., N. 34°–37° E., 70°–80° W. to 90° and 85° E.;] same, in line of 118th St., 70 yds. W. of 9th Av., N. 42° E., 90°, 80° E. to 80° W. Just W. of Morning Side Park, five observations commencing at the most southern, *m. gn.* N. 24° E., 60° W.; N. 29° E., 80° W. to 90°; N. 34° E. 90°±; N. 33° E., 90°±; N. 33° E., 90°±.

On St. Nicholas Av. and 125th St., N. 28° E., 90°±; same Av., along Convent Grounds, between 126th and 129th Sts., N. 27° E., 90°, some *hblc.* and near 126th St. granite veins, and above 129th St. N. 30°–31° E., 70° W., var. to 60° W. On S. part of Convent Grounds N. 22° E., 50° E. On S.W. part of Convent Grounds, three observations, N. 22° E. average, 65° W., var. to 50° and 70° W.; W. part of same grounds, near the fence, *m. sch.* and *m. gn.* N. 30° E., 70° W. Near N. end of same grounds N. 32° E., 70°–60° E., and near its middle, *m. gn.* N. 27° E., 70°–75° E. On St. Nicholas Av., near 138th St., *m. gn.* and *m. sch.* N. 33° E., 80° W. to 80° E., mostly E.; near 144th St. N. 32°–37°–27° E., 70° E., much contorted; near 145th St. N. 26° E., 90° and to E. of last on 145th St., N. 30° E., 90°, 80° E.

E. Between 8th and 10th Avenues, North of 155th Street.—At 156th St. N. 14° E., 70°–80° W., N. 28° E., 75° W.—161st St., N. 19° E., 80°–65° W.—Between 161st St. and reservoir, N. 24° E., 80°–65° W., N. 38° E., 80° E. to 90°, N. 19° E., 80° W.—Near river, below reservoir, N. 20° E., 70° W.—Within 120 rods N. of reservoir, along 10th Av., N. 28° E., 70°–80° E.; N. 29° E., 65°–70° (varying to 50°) E.; On slope toward river, N. 30° E., 80° W. to 90°; N. 30° E., 90°; N. 37° E., 80° E. to 90°.—Between 120 and 180 rods N. of reservoir, along 10th Av., N. 19° E., 80°–85° E. (var.), N. 23°–24° E., 80° E. to 90°; On slope toward river, N. 27° E., 90° E.; N. 38° E., 80°–70° W.; N. 30° E., 90°; N. 31° E., 80° W.—Farther N. on 10th Av., S. of Sherman's Creek, N. 21°–32° E., 80° E. to 80° W. (west side of road); large granite veins; N. 7°–22° E., 60° E. to 70° E. (east side of road); [west side of road nearly opposite, N. 22°–7° E., 50° E. to 65° W., and varying just south to 70° W. and 20° W.]; N. 55° E., 35°–30° E. (E. side of road); N. 83° W. to 72° E., 30°–40° E. (E. of road); N. 27°–32° E., 65°–70° W. (on top of ridge).—Farther N.E. toward Sherman's Creek, N. 8° W., 50° W. (40°–60°); N. 12° E., 65°–70° W.

F. On or West of 10th Avenue, South of 155th Street.—Near 10th Av. S. of 125th St., *m. gn.* N. 30° E., 80°–75° E.; N.E. corner of 130th St. and Broadway, N. 29°–30° E., 80° E. to 90°; On 10th Av., N. of 133d St., N. 26° E., 75°–65° E., and near 136th St., N. 32° E., 75° E. to 90°.

On 11th Av., N.W. corner with 131st St., under house, *m. gn.* N. 28° E., 80° E. to 90°; on 132d St., *m. gn.* N. 23°–25° E., 90°; W. of 11th Av., on N. side of 133d St., N. 23°–30° E., 90° to 8° W.—In "Park," near corner 10th Av. and

133d St., *m. gn.* N. 20° E., 90°, 80° E., and near 11th Av., N. 28° E.. 70° E., and in line of 136th St., N. 39° E., 50° E. (varying to N. 55° W., 35° W.—On 11th Av., N. of 157th St., N. 30° E., 80° E. (average); in line of 137th St., N. 19° E., 70° W. to 80° E.; same Av. and 148th St., *m. sch.* to thin *m. gn.*, N. 25° E., 90°, 80° E.; same Av., but nearly half way to 10th, above 145th St., N. 28° E., 80°–75° E.; [same Av. and 147th St., E. side, N. 28° E., 85° W. to 85° E.].

G. On or West of 10th Avenue, and on or North of 155th Street.—On 11th Av. near 160th St., N. 22°–30° E., 70°–65° E.; [same Av. and 161st St., S.W. corner, N. 26° E., 90°–70° E.]; same Av., 162d St., N. 28° E., 90°–80° E.; [same Av., 163d St., N.E. corner, N. 29° E., 90°–80° E.]; same Av. and 164th St., N.E. corner, N. 29° E., 90°–80° E. Near junction of 11th Av. and Kingsbridge Road, N. 17° E., 90°. On Kingsbridge road and 165th St., *m. gn.* N. 29° E., 90°; same and 187th St., N. 29° E., 65° E. Near Hudson River, 155th St., 100 yds. off, *m. gn.*, N. 14°–22° E., 90°, 80° E. On Hudson R. railroad, nearly in line of 163d St., N. 22°–24° E., 70°–80° E., var. beyond to 55° E.; on R.R., W. of Deaf and Dumb Inst., dip 65° W.; on R. R., W. of Inst. for Blind, N. 24° E., 70° E.; on R.R., 100 yds. S. of Ft. Washington Station, *m. gn.* N. 22° E., 60°–70° E.; on R.R., just N. of Ft. Washington Station, N. 31° E. to N. 37°, 60°, 70°, 55° E.; on R. R., 150 yds. farther, *m. gn.* N., N. 20° E., 70° E. varying to 60° E.; on R. R., 500 yds. S. of Inwood Station, *m. sch.* N. 23° E., 70° E.; on R.R., 200 yds. S. of Inwood Station, *m. gn.* N. 23° E., N. 20°–30° E., 70°–65° E.; same, adjoining station, N. 34° E. Just E. of Inwood Station, *m. gn.* N. 49° E., 55°–65° E., but on N. side of road, N. 33° E., 60°–70° E.

H. North of Sherman's Creek and Inwood Street.—W. of Farmer's Bridge over Harlem, S. of Kingsbridge, *l.* N. 12° E., N. 32° E., N. 37° W., best N. 32° E., dip 90° to 80° W.; going S., just S. of first brook-crossing, *l.* N. 24° E., 75° E. to 90°; 180 yds. farther S., *l.* N. 38° E., 75° E. to 90°; farther S., positions of next 4 T-symbols, on W. side Kingsbridge Road, *l.* N. 47° E., 50° to 60° E.; N. 60° E., 60°–65° E.; N. 75° E., 45° E.; N. 55° E., 75° E. Over 100 yds. W. of Kingsbridge Road, at loc. of the northern of 3 T-symbols, N. 50° E., 60° E.; at loc. of other 2, N. 67° E., 55°–65° E. (varying to N. 75° E.).

At Inwood St., a bed of *m. sch.* in *l.*, and E. side of Kingsbridge road, *m. sch.* N. 60 E., 60° E.; here 150 yds. E. of Kingsbridge road *l.* N. 58° E., 60° E.; farther S., W. of head of Sherman's Creek, *l.* N. 40°–43° E., 60°–70° E.; 350 yds. S. of head of Sherman's Creek *l.* N. 38° E., 65° E. (most southern outcrop observed).—On Inwood Parade Grounds N. of Sherman's Creek, 4 T-symbols, commencing with the easternmost, *l.* N. 7°–16° E., 70° E.; N. 22°–27° E., 70° E.; N. 17° E., 60°–65° E.; N. 48° E., 70° E. (At the more eastern outcrops a large granite vein in the limestone, having the course N. 15° E., corresponding with the strike of the enclosing *l.* and also an intercalated bed of *m. sch.*, having the strike N. 12°–32° E., dip 70°–80° E.

2. Outside of New York Island, in Westchester County.

On or near Limestone Area No. 1.

a. South of 148th St. and E. of 3d Avenue.—E. of Brook Av., in 133d St., *m. gn.* N. 24°–32° E., 80° E. to 90°; on St. Ann's Av. in 136th St., *l.* N. 37° E., N. 32°–35° E., 80° W. to 80° E., near 138th St., *l.* N. 32° E., 80° E.; [in 140th St., E. of St. Ann's Av., *m. gn.* N. 26°–28° E., 90°]: between 142d and 143d St., *l.* N. 22° E., 75° E.; in 143d St., *l.* N. 17° E., 75° E.; in 146th St., N. 22° E., 90°.—Between Brook Av. and Willis Av., N. of 134th St., *m. gn.* about N. 22° E., undulating, 15°–20° E., and to eastward N. 37° E., 65° E., and N. of 135th St., *m. gn.* N. 37° E.. 40° W., varying much; N. of 136th St., near the *l.* belt, *gn.* N. 31°–37° E., 80° W. to 80° E.; between 139th and 140th St., N. 24° E., 75° E.

Port Morris, E. of R.R., *m. gn.* or *sch.* with many granite veins and much contortion. best N. 29° E., 70°–75° E.; W. of R.R., same, N. 27° E., 75° W.—N. of Port Morris, E. of Boulevard on branch R.R., *m. sch.* or *gn.*, N. 28°–47° E., 60°–70° W, but varying much; still many granite veins; W. of Boulevard, W. of last, S. of 144th St. on R.R., N. 28°–24° E., 60°–70° W.

b. South of 148th St., and West of 3d Avenue, about Mott Haven.—E. of R.R., *l.* N. 26°–34°—15° E., 90°, 70° W., much contorted; [on S. side of N. ledge of *l.*, *m. sch.* N. 25° E., 75° W.]—W. of R.R., S. of station, ledge of *m. gn.* and *m. sch.*, N. 26° E., 60°–80° W.; on 138th St., W. of *l.*, *m. gn.* N. 24°–32° E., 60° W., [and 50 yds. farther N., N. 17° E., 80°–60° W.]—N. of Mott Haven Station, N. of 138th St., along R.R., *l.* N. 18°–20° E., 90° to 70° W., and 100 yds. N. of station, *l.* N. 20° E., 50°–70° W., *m. sch.* in *l.* rusting from pyrite present; on 144th St., W. of Mott Av., *m. gn.* N. 14° E., 60° W., and N. 22° E., 70° W.

c. Between 148th Street and 163d Street.—W. of Harlem R.R., between Mott Av. bridge over Hudson River R.R. and Harlem R.R., *l.* N. 15° E., 60° to 80° W. and E., *l.* extending 520 feet W. of R.R.; at the bridge and W. of it *m. sch.* and *m. gn.* much contorted N. 22°–32° E., 26°–80° W., local flexures; N. of bridge, *gn.* observed to be fibrolitic; 250 yds. N. of bridge on Mott Av., *m. gn.* N. 24° E., 70° W. [E. of Mott Av.. 100 yds. N. of junction of the two R.R., in a small hill, *l.* N. 13°–18° E.]; E. of St. Ann's Av., near 149th St., N. 23° E., 90° to 60° W.

On Harlem R.R., below 158th St., *l.*, and near 160th St., N. 22°–27° E., 90°, to 30° W., E. of Harlem R.R., and W. of 3d Av., on 149th St., *l.* N. 22° E., 35°–45° W.; near 150th St., large undulations, N. 22° E., 0°–45° W. and E.: just below 155th St., W. side of Elton Av., *l.* N. 22° E., 0°, 20° to 30° W., and E. side of same Av., *l.* N. 22° E., 35° W. to nearly horizontal and 50° E.; on 156th St., E. side Elton Av., *l.* N. 19° E., 45°–25° E. and horizontal; above 159th St. on Elton Av., *l.* N. 18° E., 35°–60° W., and W. of Av., N. 22° E.—150 yds. E. of St. Ann's Av. near 149th St., *m. gn.* N. 23° E., 60° W. to 90° [161st St., *l.* N. 22°–28° E., 90°–30° W.]; [162d St., 100 yds. W. of Harlem R.R., *l.* N. 24°–26° E., 70° W.

d. North of 163d Street, East of Harlem R.R.—South of Tremont on 167th St., near Washington Av., *l.* N. 19°–15° E., 80° W. to 80° E.); on 166th St., 100 feet E. of Washington Av., *l.* N. 19° E., 70° E.; between 167th and 168th Sts., W. of same Av., *l.* N. 20° E , 70° E.; 40 feet E. of the Av., *l.* N. 26° E., 90° to 80° E.—Just E. of 3d Av. on Boston Av., *m. gn.* N. 21° E., varying to N. 27° E., 60°–70° E.; on 167th St., thin *m. gn.* N. 15° E., 70°–80° E.; on 169th St., N. side, just W. of Fulton Av., *m. sch.* or *gn.* N. 14° E., 70°–60° E., varying much.—In Tremont, W. of 3d Av., near 170th St., *l.* N. 27° E., 90°; on 172d St., N. 28° E., 90°; farther N., *l.* N. 21° E., 90° to 70° E.; To eastward on Locust Av., E. of 3d Av., *m. gn.* and *sch.* N. 18°–29° E., 90°–70° E. [E. of Bronx R. in West Farms, *m. gn.* N. 18° E., 70° E.].—Half way from Tremont to Fordham, E. of Fordham or 3d Av., *m. sch.* N. 21° E., 90°–75° E.

In Fordham, *l.* near R.R. station, E. side of Kingsbridge road, strike not distinct in the small outcrop.

N. of 163d St. and West of Harlem R.R.—In Fordham, on road going W., *gn.* N. 28° E., 90° to 80° E., and 200 yds. farther W., N. 28° E., 90°; S. of last on 1st road W. of R.R., gray *gn.*, with some *m. gn.*, N. 26° E., 70° E. and N. 29° E., 70° W.; ¼ mile and farther S.W. just W. of same road, observations corresponding to 8 T-symbols in succession, N. 30° E., 70° E. and N. 30° E., 75°–80° W., the easterly predominating; N. 30° E., 70° E.; N. 30° E., 90° to 80° E. and N. 30° E., 90° to 80° W.; N. 26° E., 60°–75° W.; N. 29° E., 80° W.; W. of Tremont Station *gn.* partly *hblc.*, N. 22° E., 40°–60° W., varying to 30°.—S.W. of Tremont, just W. of limestone area, observations corresponding to 5 T-symbols, *quartzytic gn.* mostly, varying to *m. gn.* N. 24° E., 90°–70° E.; N. 27° E., 60°–40° W.; N. 21° E., 60°–30° W.; N. 31° E., varying W. dip.; N. 18° E., 70°–60° W., but varying much.

In Fleetwood Park, N.E. side, *m. gn.* undulating; in E. part of ledge, N. 28° E., dip 60° E., but just W. bends over and dip 45° W., then 50°–80° E. again; W. part of same ledge, N. 16°–22°–24° E., 75°–55° W.—In center of the Park, *l.* N. 24° E., 75° W.; 75 yds. more to W., *l.* N. 28°–30° W., 60°–65° W.; to N.W. of last, near schist of W. side of Park, *l.* N. 28°–30° E., 60°–70° W.; W. part of Park, *m. gn.*, near *l.*, N. 28° E., 65° W.; farther S.W., *m. gn.* N. 32° E., 55°–65° W.

W. of Fleetwood Park, near W. entrance, *m. gn.* N. 24°–26° E., 70°–80° W.; 200 yds. N.E. of last, on Av. adjoining Park, *m. gn.* N. 26° E., 70°–80° W.; same road farther N. in line with N. side of Park, *m. gn.*, N. 8° E., 80° E. to 80° W.—And

N. 13° E., 90° about; 250 yds. N. of Park, *m. gn.* N. 26° E., 85° W.; near N. end of this schist on Arcularius St. and same Av., *m. gn.* N. 20° E., 90° ±. and 50 yds. more to W., N. 19° E., 70° W. (T-symbol wrongly makes it E.).

Just N. of Fleetwood Park, *l.* (continuation of that of the Park), observations corresponding to 5 symbols, N. 22° E., 90°; N. 18° E., 90° ±; N. 18° E., 90°: N. 19° E., 70°–80° W., N. 19° E., 80° W., the last near end of the gneiss a little beyond line of Arcularius line: here the limestone becomes that of Area No. 2.

Area No. 2 and its vicinity.—Commencing at the north ¼ mile N. of Manhattan House (M on map), on Central Av., W. side, *m. gn.* N. 32° E., 50°–65° E.; 300 yds. N.W. of same house on same Av., *m. gn.* N. 27° E., 65° E.; 100 yds. W. of same house on road going W., *m. gn.* N. 30° E., varying, 55°–60° E., and 400 yds. farther W., N. 30° E., 65°–70° E., varying; 400 yds. N. W. of Club House (C on map), *m. sch.* N 28° E., 50°–60° E.; [800 yds. S.W. of same, N. 23° E., 50°–60° E.].—In Mt. Eden limestone region, 3 T-symbols, N. 12° E., 70°–80° W., (near a barn), N. 2° E., 60° W., N. 2°–12° E.; 45°–20° E., undulating: and to S.E., 4 T-symbols, N. 17° E, 60° W.; N. 12° E., 60° W., N. 27° E., 60°–65° W., N. 31° E., 70°–65° (the last near bottom of valley west of Mt. Eden region); [again, near last, N. 21° E.]

Near head of Cromwell's Creek (the bay E. of lower part of Central Av.), and where Central Av. crosses the brook, W. of brook, on road going N.W., *m. gn.* N. 12°–19° E, 60°–65° E.; N. 14° E., 55° E., some *hblc.* layers; [near the last, W. of road, near house, N. 21°–23° E., 65°–70° W.]; little to S. on Central Av., W. side, *m. gn.* N. 31° E., 68° E.—East of brook (and "Judge Smith's House"), *l.* N. 24° E., 40° E.; N. 27° E., 36°–40° E.; more to E. near limit of *l.*, *l.* N. 21° E., 60°–65° E.; and E. of last, *m. gn.*, N. 21° E., 65°–70° E. (the T-symbols of last two observations wrong in the stem pointing W.).—W. of middle of Cromwell's Creek, on Central Av., W. side, *m. gn.*, N. 23° E., 65°–75° E.; to S. of last, N. 32° E., 80° W. to 90°.

E. of S. part of Cromwell's Creek, on 1st St., *l.* N. 16° E., 90° ±; 225 yds. to N.E. of bridge, thick bedded *l.*, N. 16° E.; just E. of last, *gn.* N. 15° E., 80° W. to 90°.—W. of S. part of same Creek: at W. end of bridge, *m. gn.* N. 20° E., 45°–60° W.; on Central Av. below High St. near Case's Hotel, *m. gn.* much contorted N. 27° W. to N. 27° E., 30° W. to 65° W.; directly W., 150 yds. N. of McComb's bridge, *m. gn.* in zigzags N. 28° E., 80° W. to 80° E.; on Central Av. 150 yds. N.E. of same bridge, dip 60° to 80° W. On Hudson River, W. of N. end of same bridge, 75 yds. W. of the Av., *gn.* N. 27° E., 80° E. to 65° E., and 120 yds. to N., near same river N. 27° E., 75° E. to 90°.

Area No. 3 and its vicinity.—At Kingsbridge, on R.R., *l.* N. 37°–40°E., 60° E.; just W. of the limestone area, on R.R., *m. sch.* or *m. gn.*, partly *hblc.* N. 42° E., 65°–70° E.; 250 yds. W. near bridge at W. side of the bend in Sp. Duyvil Creek, *m. gn.*, N. 56° E., 70°–60° E. (here layer of actinolite, etc.). W. side of Tibbit's Brook, 4 to 5 miles N. of Kingsbridge, *m. gn.* N. 18°–24° E., 60° E.

Area (No. 3A) north of Spuyten Duyvil to Riverdale, on the Hudson.—At Spuyten Duyvil, near old R.R. station, *m. gn.* N. 40°–75° E., 35°–60° E., contorted, varying widely; 60 yds. S., N. 50°–37° E., 45°–50° E.; 50 feet N. of forking of R.R. above same R.R. station, *m. gn.* and *gn.* N. 47° E., 70° E.; about 200 yds. N.N.E. of last, and as far from river, *m. gn.* with some *l.*, N. 47° E., 60° E.; on Whiting estate, S. of E. of an old limekiln. *l.* quarried, N. 17° E., 70° E., but varying in strike and dip; 250 yds. N.E., *gn.* of E. side of *l.* area, part *hblc.*, N. 4°–8° E., 55°–60° E.; [S. of Delafield's, *gn.*, part *hblc.*, N. 10° E., 60° E., 55°–65° E.]; W. of same, large quarry of *l.*, part tremolitic, N. 10°–18° E., 60°–70° E.; E. of Riverdale station, N. of *l.* area, *m. gn.* N. 30°–34° E., 65° E.; [S.E. of Mt. S. Vincent grounds, quarries of *m. gn.*, N. 34° E., 60°–55° E.; on R.R. near Mt. St. Vincent depot, N. 17°–22° E., 55°–65° E.].

Area 4.—S. of W. Mt. Vernon ¾ mile, W. side of R.R., *l.* N. 29° E., 70° E.; E. of R.R., *l.* same; E. of *l.*, *thin gn.*, same; on ridge between W. Mt. Vernon and Mt. Vernon, *thin gn.* N. 21°–25° E., 70°–75° E.; on N. Y. R.R., below Mt. Vernon, *thin* or *m. gn.* N. 27° E., 65°–70° W.; at W. Mt. Vernon. E. of R.R., *m. gn.*, N.

20° E., 65°–75° W., and W. of Bronx River near Williams Bridge, thick *gn.* N. 20° E., 90° to 80° W.; *m. sch.* and *m. gn.* on W. side of R.R., S. of Woodlawn, N. 18° E., 82° E.; at Williams Bridge, W. of R.R. track, *m. sch.* N. 20° E., 60° E., and E. of river, same.

Area 5.—In New Rochelle, N. of Davenport's Neck and of the Serpentine loc., thin *m. gn.* N. 19° E. and N. 27°–38° E., 85° E. to 85° W.; on S.E. and S. shore of Davenport's Neck, S. of Serpentine loc., *m. gn.* N. 27°–43° E., 70°–85° E.; between N. Rochelle and Mt. Vernon, to the E., *m. gn.* (but partly whitish gneiss), to the W., *m. sch.* and *m. gn.*, N. 20° E. (average) 90°, the 8 T-symbols on map correspond, commencing on the east, to N. 25° E., 90°; N. 24° E., 90°; N. 21° E., 85° W., N. 20° E., 85° W.; N. 27° E., 85° W.; N. 15°–25° E., 90°–80° W.; N. 20° E., 78° W.; N. 21°–25° E., 70° W.

In Marmaroneck, *m. gn.*, near R.R. depot, N. 37° E., 70°–85° W.; the 4 T-symbols to N.W. correspond to N. 39° E., 80°–85° W., rock same; N. 37° E., 90°, 80°–85° E., *hard gn.*; N. 29° E., 80°–85° E., *hard gn.*; N. 29° E., 80°–85° E., same *hard gn.*; N.W. of last, in Scarsdale, *m. gn.*, N. 17° E., 90°–70° W.—South of New Rochelle the 7 T-symbols correspond to: *m. sch.* or *m. gn.* N. 24° E., 90° and 85° E. to 85° W.; same, dip 80° E.; N. 22°–32° E., 70°–80° E., much contorted; N. 18° E. (average), 80° E.; N. 24°–30° E., 90°, 85° E.; N. 27°–30° E.; N. 37°–47° E., 90° ±; N. 30° E., 90°; N. 24° E., 90° to 80° E.; N. 20°–23° E., 80° E. to 90°.

Area 6.—At Portchester, thin *m. gn.* (brilliant mica scales white and black, white predominating), N. 10°–12° E., 65°–70° E.; N. of Portchester, *m. gn.* N. 10°–18° E., 70°–75° E.; N. 7°–12° E., 60° E.; W. of Serpentine, N. 11° E., 90°, N. 21°–27° E., 75°–80° W., N. 14° E.—3 miles N. of Portchester, same *m. gn.* N. 37°–67° E., 22°–42° W.—W. of Glenville, same brilliant *m. gn.*, N. 32° E., 30° W.; N. 37°–76° E.; 30°–50° W.; N. 37° E., 30° W.—N. of Serpentine area *m. gn.* N. 37° E., 30°–35° W.; S. of Serpentine area, N. 17°–58° W., 30°–50° E., but with great contortion var. to N. 24° W., dip 30°–45°–50° E.; farther S., just N. of R. R., N. 20° E. (but var. much), 65°–70° E.

Areas 7, 8.—*m. sch.* or *m. gn.*, E. of Yonkers, N. 16° E., 70° E.; N. of last, W. of river, and of N. end of cemetery, N. 12°–37° E., 55°–60° E.; ½ mile more to N., N. 32° E., 60°–70° E.; Yonkers to R.R. south of Bronxville, the 5 T-symbols, thin *m. sch.* N. 15° E., 65° E.; *gn.* N. 27° E., 85° W.; same, N. 27°–30° E., 65°–70° W.; thin *m. gn.* N. 24°–27° E., var. to N. 14° E. and N. 38°E., 90° to 85° W.

Area 9.—*l.* N. 10° E., 86° W.; W. of *l.*, thin *m. gn.* N. 18°–19° E., 85° E.–85° W.

Area 10.—The Tuckahoe belt extends little S. of bridge at Bronxville; E. of river, S. and N. of R.R. depot, *hard gn.*, contorted, N. 23°–26° E., 90°–70° E., 85° W.; W. side of river, near bridge, *gn.* N. 20° E., 60° W.; ½ mile N. of depot, on R.R., *gn.* N. 23° E.; W. of this point in the marsh of the valley, *l.* N. 26° E., 90°; 50 yds. N., *l.* outcrops E. of R.R.—West of Bronx R., between Bronxville and Tuckahoe depot, hard *gn.*, N. 20°–24° E., dip W.; 1st, *l.* quarry N. of Tuckahoe depot, *l.* N. 35° E., 65° W.; E. of *l.* is *m. sch.*, N. 35° E., 60°–70° W.

Area 11.—In Scarsdale, along R.R., N. and S. of depot, *l.* N. 26°–28° E. [also N. 10°-35° E.], 55°–60° W.; ½ mile E. of depot., *hard gn.*, and some *hbl.* schist, N. 26° E. (var. to 40°), 60°–80° W.; again, ¾ mile S.E. from depot *m. gn.* N. 28° E., dip 65° W. The *l.* N. of depot a very narrow strip; narrow valley continues toward Hartsdale. ½ mile N. of Scarsdale depot, W. of river, *l.* near river, which continues N. through Fox Chapel Garden grounds, 75–100 yds. wide; *granitoid gn.* E. of *l.*, N. 18°–28° E., dip 60°–65° W.—In Hartsdale, in road going E. from depot, *l.* N. 18° E., 45° W., but ¼ mile E. of depot, *m. sch.*, N. 18°–24° E., dip 60°–65° W. and ¾ mile W., whitish *gn.*, N. 17°–19° E., 60° W.—From Hartsdale nearly to White Plains a narrow marsh along east side of river.

Area 12.—1½ mile N. of White Plains, outcrop of *l.* from beneath stratified drift, N. 13° E., 46° W.; 400 yds. N. of railroad station at White Plains, banded *gn.*, partly *hblc.*, N. 30°–37° E., but var. to N. 42°, 56°, 72° E.; 2 miles E., on road to Rye Pond, firm *gn.*, N. 22° E. to N. 50°–60° W.; ¼ mile farther N.E., reddish granitoid *gn.*, N. 27°–42° E., 50° W.; nearer Rye Pond, gray *gn.* much contorted.

AREA 13.—East of Dobbs Ferry, hard *gn.* N. 3°–22° E. and N. 11° E., 90°; at Ashford, *hblc. gn.* N. 25° E., 60°–70° E.; ½ mile E. of Hastings, hard *gn.* N. 17° E., 90°–80° E.; 1 mile E. of Hastings, near Sawmill R., *gn.* N. 24° E., 65° E.

AREA 14.—About 3 miles N. of Ashford *l.* commences, the rock in the valley there dark gray *gn.*; ½ mile N. of this, *l.* N. 22° E., 80° E.; at E. Tarrytown, ½ mile E. of river, on E. border of the broad valley, *l.* N. 32° W., 45° E.; again N. 28°–33° E., 90° to 80° E.; W. of river, is compact *gn.*, contorted, N. 27°–32° E., dip 60° E.; E. of river, 1 mile N. of E. Tarrytown, a bluff of *l.* to east of road, N. 47° E., dip 70° W.; ½ mile S.W. of Unionville *l.*, N. 24° E., 70° W. to 70° E., the latter prevailing.

AREA 15.—275 yds. S. of Unionville depot, E. of R.R., *l.* N. 24° E., dip 75° E. In Pleasantville, S. of R.R. depot, *l.* N. 37° E., 60° to 80° E., here an intercalated bed of *m. sch.*; 50 yds. N. of depot, *l.* N. 30°–34° E., 90° to 70° W.; ¾ mile E. of depot, on "Broadway," *l.* N. 18° E., 80°, and more to N. dip 40° E.; E. of *l.* ¼ mile, thin *gn.*, N. 40°–43° E., 90° to 80° E. At Chappaqua, *l.* about 250 yds. in width. 1½ miles E. of Pleasantville depot, an outcrop of *l*, N. 3° E., 50° W., area small; W. of *l.*, *m. gn.* N. 12° E., 70° W.; 1½ mile S.E. of *l.* toward Armonk, grayish *gn.* N. 9° E., 55° W.

AREA 16.—S. of Sing Sing R.R. station, *l.* N. 37° E., dip 55° E., again N. 30°–42° E., 70°–80° E.; near N. end of prison, *l.* N. 32° E., 40°–50°–60° E.; E. of prison, on Spring St., *l.* N. 24° W., 20°–30° E. Abreast of station, *m. sch.* N. 25°–40° E., 70°–80° E.; S. of *l.* area, in Scarborough, *m. gn.* N. 23°–40° E., 50°–60° E.—Along brook near entrance to Dale Cemetery, *l.* N. 20° E., 40°; ½–¾ mile E. of last, near road to Camp Woods, *l.* N. 64° E., 40° E.; ½ mile N. of entrance to Cemetery, on road, *m. sch.* N. 54°–74° E., 90° to 80° E., contorted; in field 60 yds. W. of last, same *m. sch.* N. 30°–38° E., with *l.* either side N. 37° E. —W. of Dale Cemetery, above junction of Post road with road next E., *l.* N. 32° E., 50° E., and W. on aqueduct, *l.* N. 58° E., with bed of granitoid *gn.* N. 58° E., 65° E.

AREA 18.—At Croton, 1 mile E. of R.R. station, 250 yds. S. of Barlow's, *l.* N. 24° W., 60° E.; near last, ¼ mile N.E. of Episcopal Church, fine-grained *l.* quarried, but bedding indistinct; ¼ mile farther N.E., *m. sch.* N. 2° E., 60° E.

AREA 19.—¼ mile S. of Croton R. at Huntersville, *l.* N. 52° E.; W. of *l.*, rusting *m. sch.* N. 52° E., 90°–80° E.; again S.W. for ½ mile, *l.* N. 52°–60° E.; toward Quaker Bridge, *l.* N. 77° E., 85° E. to 90° and 85° W.

AREA 20.—At Merritt's Corners, *l.* N. 36°–44° E., 60° E.; 1 mile N., *gn.* N. 42° E., 70° E.

AREA 21.—On east side of Croton Lake, coarse cryst. *l.* mostly N. 7°–22° E., contorted, average N. 14° E., 60° W.–90, *l.* contains graphite; *gn.* on east side of *l.*, contorted (mica black), N. to N. 30° E. average N. 14° E., 55°–60° W.; *l.* extends into lake.

AREA 22.—E. and S. of depot, *l.* much contorted, N. 12°–40° E., dip W.; 200 yds. S., N. 62°–67° W.; dip E. farther south, N. 40°–42° E., dip W.; on hill to E., *m. sch.*, with granite, N. 40° E., 50° W., again, *m. sch.* and *gn.* N. 37°–42° E., 45° W.

AREA 23.—1 mile N. of south extremity of area, *l.* N. 8° W. to N. 10° E., 60°–65° W., varying to 40° W.; *gn.* in contact with *l.* and conformable, the *gn.* partly hard feldspathic; W. border of river-valley, *gn.* N. 5°–11° E., 40°–60° W. Near S. end of area, and for 1 mile E., *m. sch.* and *thin gn.* N. 10°–11° E., 40°–60° W.—East of Armonk, E. of Byram R., *l.* N. to N. 5° E., W. 60°; ½ mile S.W. of Armonk schistose *gn.* N. 15° E., 55° W. [Between this point and Kensico depot, going S.W., N. of Kensico village, hard whitish to reddish gneiss, N. 12°–22° E., 90°±; N. 14°–40° E., 90°–80° W.; S. of Kensico village, hard gray *gn.* (black mica) N. 12° E., 60° W., same, N. 14°–27° E.].—Near N. extremity, just W. of Byram Lake, twisted *gn.*, N. to N. 60°–38° W., N. 7° E.; N.E. border of lake, thin whitish *gn.* N. 8° W., N. 22° E., 45° W., contorted, again thin *gn.* N. 2° E., again dipping under last thick bedded feldspathic partly banded

and gneissoid; again ¼ mile E., thin *gn.* N. 8° W., 40°–45° W., some *hbl.* portions. No *l.* in sight, being two feet under water in lake.

AREA 24.—S.W. of area, *gn.* N. 24° E., 40° W.; S.E. of area, *gn.* N. 8° W., 50° W.; W. of valley, 1 mile N. of S. end of area, *m. gn.* (mica black), N. 8° W. to N. 22° E., varying to N. 67° E., 10°–35° W. In Bedford village, N. margin of area, *l.* N. 57° E., 40° W.; near head of Mianus R., *l.* N. 84° E., 60° N., varying to N. 48° W., 40° W.; just to E., 300 yds. S. of road, *l.* N. 67° E., 55° W., and E. side of same low hill, consists of *granulyte* (cream-colored orthoclase and a few garnets), N. 57° E., 65°–70° W.; 300 yds. E. of last, after passing the granulyte, more *l.*; limestone valley here fronted to N. by a high, nearly E. and W., precipice of bedded *gn.*, strike of *gn.* N. 62° E., 25° W. 1¾ mile E. of Bedford village, *gn.* N. 3° W. to N. 17° E., 65°–70° W.; 2 miles to 2½ E. of Bedford village, thin to thick *gn.* N. 42° N., 45°–50° W.

AREA 25.—East of N.E. end of area, *m. gn.* or *m. sch.* N. 21° E., 50° W.; ¼ mile S.W., thick-bedded *gn.*, porphyritic with some thin micaceous layers, feldspar crystals ¾–1½ inches long, N. 24° E., 55° W., changes to reddish granite; *l.* outcrops to W., but bedding not distinct; 1 mile S.W. of last, thin *gn.*, N. 24° E., var. to N. 42° E., dip W.; ¼ mile W. of W. end of area, thick-bedded *gn.* N. 57° E., 35°–40° W.

AREA 26.—1¼ mile S.W. of Ridgefield, *m. sch.* N. 37° E., dip 38° W.; 1 mile farther S.W., *l.* N. 3° W. to N. 14° E., 55° W.; 1 mile S.W. of last, and ¼ mile W. of *l.*, *gn.* N. 25° E. (average), dip 45°–60° W., again N. 18° E., 55° W.—Near S. end of area, E. of Pound Ridge, W. of lower pond of Trinity Lake, *l.* N. 25°–40° E., 50° W., adjoining *l.* to E., *hbl. sch.* N. 22° E., 55° W.; then E. of this, *l.* N. 12°–22° E., 50°–55° W., and next, rusting *m. sch.* On E. border of valley whitish *gn.* (the mica white), N. 47° E., 45° W.; just east of this, white granulyte (some triclinic feldspar in it), dip W.—Near Pound Ridge, W. of *l.* area, *gn.* (thin to thick-bedded) N. 47°–50°–37° E., 45°–50° W.; ¼ mile to S., rusting *m. gn.*, N. 27° E., 60° W.

AREA 27.—At Cruger's, on R.R., S. of station, N. end of cut, *l.* N. 53°–57° E., dip 60° W.; S. end of cut, N. 81° W., 40°–45° E. (or N.), much jointed; N. side of cove S. of *l.*, 225 yds. from R.R., *l.* N. 28° W., 40° E., beyond up the cove, *l.* N. 53°–63° W., 60° E., and near eastern limit of limestone, *l.* N. 68°–75° W., 70°–80° E.; gneiss along road near by and adjoining the bridge N. 68°–78° E., 65°–80° E.; up slope to north, *m. sch.* and *gn.*, N. 82°–72° E., 70°–80° W. (or N.) and *l.* N. 78°–85° W., 70° E. (or N.); on shore, S. of this cove, gray and flesh-colored *gn.* N. 14° E., 68°–80° W.; in eastern part of *l.* area, *l.* N. 73°–78° W., and *m. sch.* adjoining about east and west, dip of both 75°–80° N., greatly contorted so that in most parts strike undeterminable. West of R.R. station, on shore, *l.* and *m. sch.*, N. 66°–80° E., 70°–85° W. (or N.); ½ mile W. of station, *m. sch.* N. 87° E., and farther W., N. 80° W.

AREA 28.—¾ mile N.E. of Verplanck Point W. of Broadway, *l.* and included *m. sch.* N. 15°–20° E.; arenaceous or gneissic *m. sch.*, 300 yds. from upper end of Broadway (at *d*) N. 7° E. to N. 23° W., 70° E.; *l.* at *j.* (on road 550 yds. W. of Church corner) N. 60° W., 70°–80° E.; some arenaceous *gn.* adjoining it, but outcrop small and poor.

AREA 29.—In Canopus Hollow, at mouth of Sprout Brook, near Iron Works, *l.* N. 47°–54° E., 60°–70° E.; adjoining quartzyte N. 47°–55° E., 60° E.; schistose band in quartzyte to south half way from the point to R.R. station, N. 47°–55°, 60°–75° E.

400 yds. S. of Annsville, on river, *l.* contorted, very fine-grained, slightly crystalline, N. 20°–44° E., N. 42° E. average, 55°–60° E.; E. side of Sprout Brook, near junction with Peekskill Creek, *hydromica sch.* N. 24°–31° E., 60° E.; up brook, at quarry, *l.* N. 32° E. to N. 8° W., 70° E.; above crossing of brook by road, *l.* N. 42°–52° E., dip W., and nearly 150 yds. N.E. of road, *l.* twisted in with *gn.*, N. 8° W. to N. 62° E., and a *gneissiod quartzyte* in the N. side of the hill, N. 67° E. (this is where the T-symbols make an X on the map, and here N. side of valley is bounded by the Highland Archæan about 100 rods distant); just S. of

boundary of county, E. of brook, *l.* N. 27°–32° E., 65°–70° E.; just N. of boundary in Putnam Co.; valley ⅛ mile wide, *l.* N. 27°–29° E., 70°–75° W.; farther N.E., under bridge (at Continental Village), *l.* (with beds of *quartzyte*) N. 45° E., partly graphitic; bordering *l.* on W., *slate* N. 53° E., 70° E.; ¼ mile N.E. of last, *porphyritic granite* (Archæan?); W. of carriage road, the valley nearly ¼ mile wide; ½ mile N.E. of last, rusting *m. sch.*, N. 17° E., 80° W. to 90°; porph. granite lies northwest of schist; here, on W. side of valley. *l.* N. 37°–44° E., dip W.; *l.* in valley nearly 100 yds. S. of Croft's mine, and thin *m. gn.* west of road; 400 yds. N. of the mine, *l.* impure, N. 25° E., 80° W., same *m. gn.* W. of road; in the valley (Canopus Hollow), between N. end of Solpue Pond and S. end of Oscawana Lake, *l.* N. 53° E., dip E., involved with *quartzytic gneiss*; valley of *l.* here ¼ mile wide, *l.* ends near where the road of the valley crosses the stream here called Canopus Creek.

Area 30A.—See Am. Journ. Sci., xx, 214, 1880, for angles. In Crom Pond street N. of Academy Grounds, Peekskill, thin *m. sch.* N. 85° E., 75°–80° S.; a small show of limestone on the road side, but it may be a loose block.

Area 30.—In Peekskill Hollow at the most N.E. outcrop of *l.* (ib., p. 369), *l.* N. 41°–48° E., 60° W.; also a quarry of *quartzyte* slabs; 100 to 150 ds. of *l.*; at Adams Corners, *l.* white and bluish, very fine grain, N. 47° E., 45°–50° E, but varying much; just below Oregon, *l.* N. 32° E., with *hydromica slate* (looking like argillyte) along side and conformable. N. outcrop of *l* seen in Peekskill creek valley south of this point.

Area 31.—1½ mile S. of E. of area, hard contorted *gn.*, N. 83° W. to N. 82° E., 80° N.; ½ mile E. of Muscoot River, *l.* nearly E. and W., dip 90°; E. of W. boundary of Somers, near Bennett's, *l.* N. 33° W., N. 8° W., N. 48° W., contorted, dip E.; N. of area, *gn.*, N. 80° E., 80° E. to 90°; ½ mile E. of Hallock's mills, *l.* N. 54° E., 62°–80° E. to 90°.

Area 32.—¾ mile to ½ mile E. of area, *m. gn.* N. 72° E. to N. 88° W., 65° N. to 90°; E. end of area, *l.* N. 74° E., dip 70° N.; near W. end, *l.* N. 72° E.; W. of area, near R.R., hard *gn.* N. 72° E.

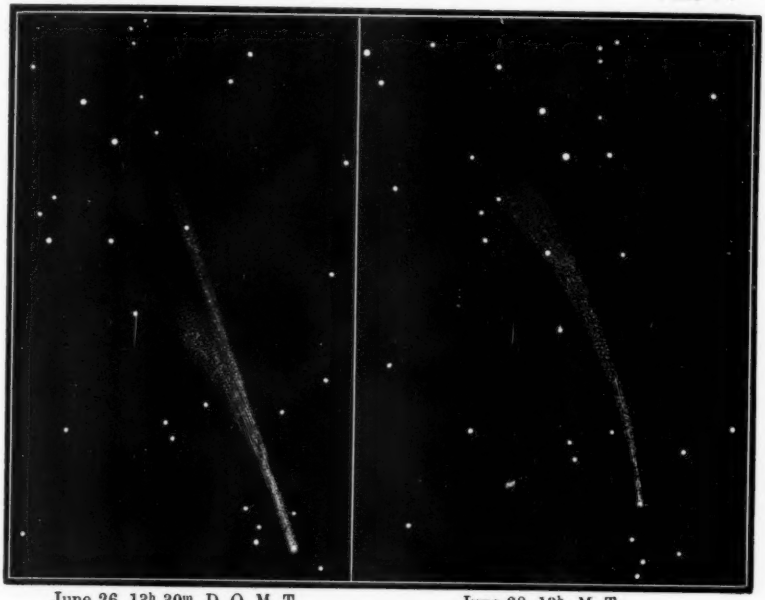
Area 34*a*.—S. part of area, *l.* nearly E. and W. to N. 57° E., dip N.; N.W. part, *l.* N. 78° W. to E. and W., 70° W.; *gn.* just N. and ½ mile S., conformable. At Golden Bridge, 300 yds. W. of station, *m. sch.*, N. 73° W. to N. 62° E., large granite vein in it; same, *m. sch.*, ½ mile N. of Golden Bridge.

Area 34*b*.—Area W. of L. Waccabuc; *l.* seen in bowlders, but not in place.

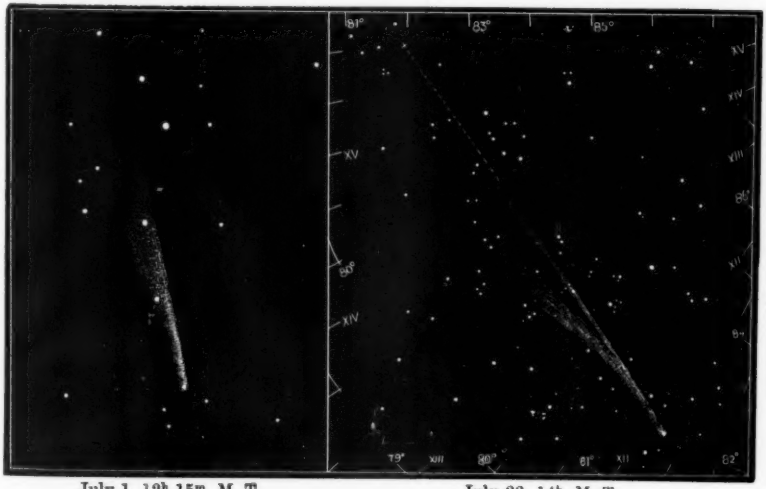
Area 35.—At neck, E. end of lake, N. of brook, *l.* N. 62°–67° E. (var. to N. 57° E.), 50° N.; just N., *m. gn.* N. 62° E., 80° N.; S. of *l.* and end of lake, *m. gn.*, N. 73° W., dip N.; nearly 1 mile E., thin *gn.*, N. 58° E.; but farther west, S. of lake, *gn.* granitoid.

Area 36.—To E. at Connecticut boundary, where the valley is very narrow (and the *l.* may be for a while interrupted), *gn.* N. 60°–62° E., 90° to 80° W.; ⅜ mile E. of N. Salem, *l.* N. 68° W. to N. 82° E., dip N., cryst. very coarse; ¾ mile S.W. of N. Salem, *l.* N. 67° E., 50°–60° W.; Salem Center, W. of cross roads, hard *gn.* (in the *l.* area) N. 57° E.; 300 yds. W. of S. Center, *l.* N. 77° E., 57° W.; 1 mile W. of Salem Center, near N. margin of *l.*, *gn.* N. 69° W.; S. of last, *l.* N. 78° W., 90°; 400 yds. to W., *l.* N. 66°–73° W., ⅛ mile; ⅛ mile W. of Decker's, *l.* N. 74°–88° W., dip 90°, and ¼ mile W. of Decker's, *l.* N. 88° W., 75° N.; N. of *l.* area, N. 88° E., 60° N.; near limekiln W. of Mrs. Bailey's, *l.* N. 87° E.; and just N., *gn.* same dip 80° N.; ¾ mile W., valley narrows, and *l.* ends.

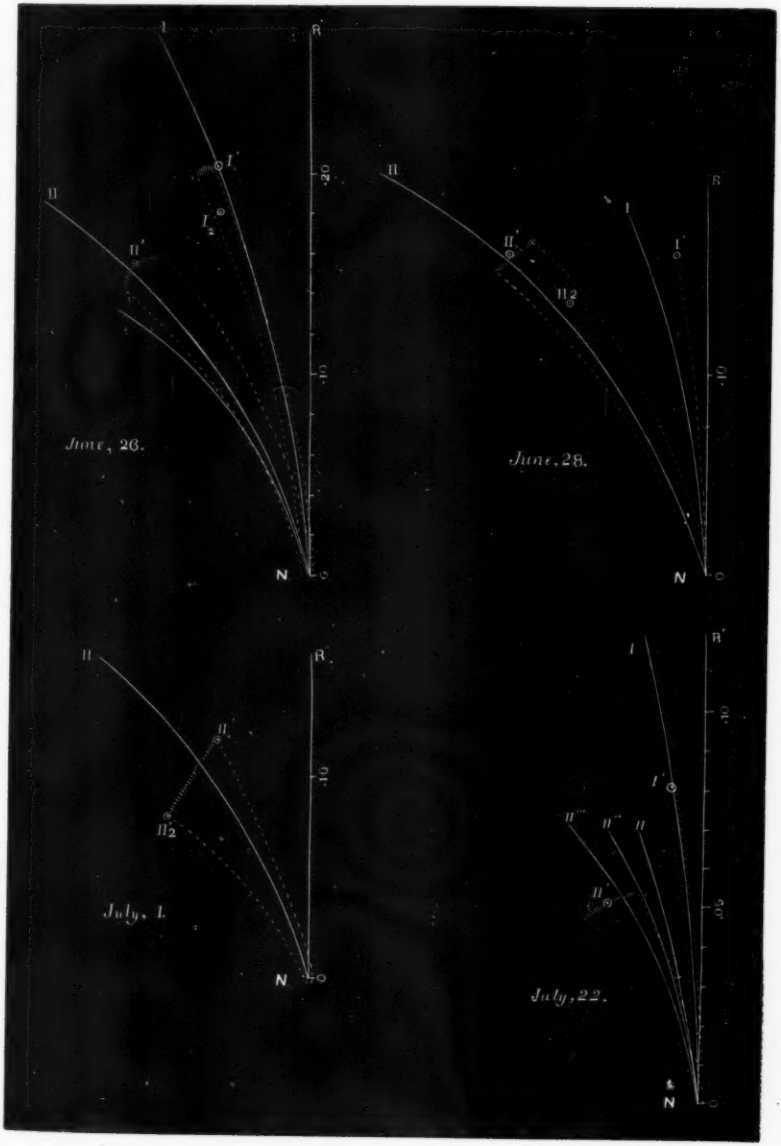
Area 37.—S. of E. end, thin *gn.* N. 88° W., 70° N.; no *l.* seen where examined, but features those of a *l.* valley. About Peach Lake, mostly hard whitish to gray gneiss, some slightly reddish; at south end strike N. 58°–73° W., dip 55°–60° E. At Croton Falls, near R.R. station, black *micaceous* rock (*hblc.*) N. 73° W., dip to north.



June 26, $13^h\ 30^m$, D. O. M. T. June 28, 13^h, M. T.



July 1, $12^h\ 15^m$, M. T. July 22, 14^h M. T.


June, 26.
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